PERIODICAL ROOM
GENERAL LIBRARY
UNIV. OF MICH.

NOV 10 1931

The Journal of HEREDITY

IDENTICAL TRIPLETS FROM JAPAN

(See Page 233)

Radiation-Induced Variation in Cotton

Breeding the Best Shorthorns

Reduced Endosperm in Maize

Nordics and Alpines

Melanin and Cancer

Schizophrenia

VOLUME 22 AUGUST, 1931 NUMBER 8

The American Genetic Association

An incorporated organization devoted to promoting a knowledge of the laws of heredity and their application to the improvement of plants, animals, and human racial stocks

DAVID FAIRCHILD, President Vice-President, W. E. CASTLE Secretary, C. E. LEIGHTY

Treasurer, MRS. G. W. SINCELL

JOHN B. LARNER, Financial Advisor Legal Advisors, PEELLE, OGILBY and LESH

EDITORIAL BOARD

Managing Editor: ROBERT C. COOK

M. DEMEREC R. R. GRAVES L. C. DUNN

H. J. MULLER GEORGE M. DARROW PAUL POPENOE

Members of the Council are ex-officio members of the Editorial Board

COUNCIL

W. E. CASTLE, Professor of Zoology, Harvard University, and Research Associate of the Carnegie Institution of Washington.

LEON J. COLE, Professor of Genetics, University of Wisconsin.

G. N. COLLINS, Botanist, U. S. Department of Agriculture, Washington, D. C.

O. F. COOK, Bionomist in Charge of Breeding Investigations, U. S. Department of Agriculture.

DAVID FAIRCHILD, Agricultural Explorer, U. S. Department of Agriculture.

HARRY V. HARLAN, Senior Agronomist in Charge of Barley Investigations, U. S. Department of Agriculture.

SAMUEL J. HOLMES, Professor of Zoology, University of California, Berkeley, California.

C. E. LEIGHTY, Agronomist in Charge of Eastern Wheat Investigations, U. S. Department of Agriculture.

VERNON KELLOGG, Permanent Secretary, National Research Council, Washington, D. C.

J. H. KEMPTON, Bureau of Plant Industry, U. S. Department of Agriculture.

E. W. SHEETS, Chief of Animal Husbandry Division, U. S. Department of Agriculture.

SEWALL WRIGHT, Professor of Zoology, University of Chicago.

ADVISORY COMMITTEE

W. S. ANDERSON, Genetics Department, University of Kentucky, Lexington, Kentucky.

E. B. BABCOCK, Genetics Department, University of California, Berkeley, California.

E. A. BESSEY, Professor of Botany, Michigan State College, East Lansing, Michigan.

A. F. BLAKESLEE, Plant Genetist, Carnegie Institution, Cold Spring Harbor, New York.

J. K. BREITENBECHER, McGill University, Montreal, Canada.

W. E. BRYAN, Professor of Plant Breeding, University of Arizona, Tucson, Arizona.

C. B. DAVENPORT, Director, Department of Genetics, Carnegie Institution of Washington, Cold Spring Harbor, L. I., New York.

J. A. DETLEFSEN, Professor of Genetics, Wistar Institute, Philadelphia, Pennsylvania.

RUSSELL W. DUCK, Professor of Animal Husbandry, Syracuse University, Syracuse, New York.

E. M. EAST, Professor of Plant Genetics, Bussey Inst. of Applied Biology, Boston, Mass.

R. A. EMERSON, Professor of Plant Breeding, Cornell University, Ithaca, New York.

C. P. GILLETTE, President, The Genetic Foundation, Fort Collins, Colorado.

C. M. GOETHE, Sacramento, California.

HARRISON R. HUNT, Professor of Zoology, Michigan State College, East Lansing.

H. S. JENNINGS, Professor of Zoology, Johns Hopkins University, Baltimore, Maryland.

D. F. JONES, Plant Breeder, Connecticut Agricultural Experiment Station, New Haven, Conn.

M. A. JULL, Senior Poultry Husbandman, U. S. Department of Agriculture, Washington, D. C.

F. B. LINFIELD, Director, Montana Experiment Station, Bozeman, Montana

C. C. LITTLE, Director, Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Maine.

JAY L. LUSH, Professor in Animal Husbandry, Iowa State College, Ames, Iowa.

H. H. NEWMAN, Professor of Zoology, University of Chicago, Chicago, Ill.

T. S. PALMER, Expert in Game Conservation, U. S. Dept. of Agriculture, Washington, D. C.

JOHN H. PARKER, Professor of Agronomy, Kansas State College, Manhatten, Kansas.

MRS. CHARLES C. RUMSEY, Wheatly Hills, Westbury, Long Island.

JOHN M. SCOTT, Vice Director, Florida Agricultural Experiment Station, Gainesville, Florida.

JOHN W. SCOTT, Professor of Zoology, University of Wyoming, Laramie, Wyoming.

A. D. SHAMEL, Pomologist, U. S. Department of Agriculture, Riverside, California.

GEORGE H. SHULL, Professor of Biology, Princeton University, Princeton, New Jersey.

W. W. SMITH, Professor of Animal Husbandry, Purdue University, Lafayette, Indiana.

CHARLES R. STOCKARD, Professor of Anatomy, Cornell University, New York City.

A. B. STOUT, Director of Laboratories, New York Botanical Gardens, New York City.

W. T. SWINGLE, Plant Physiologist in Charge of Breeding Investigations, U. S. Department of Agriculture, Washington, D. C.

LOU D. SWEET, Seedsman, Denver, Colorado.

W. H. TOMHAVE, American Aberdeen-Angus Breeders' Association, Chicago, Ill.

H. E. WALTER, Professor of Biology, Brown University. Providence, Rhode Island.

H. J. WEBBER, Director, Citrus Experiment Station, Riverside. California.

E. N. WENTWORTH, Armour's Bureau of Agr'l Research and Economics, Chicago, Illinois.

P. W. WHITING, Department of Biology, University of Pittsburgh, Pittsburgh, Pa.

The

Journal of Heredity

Vol. XXII AUGUST, 1931 No. 8

IN THIS ISSUE

A Set of Dichorionic Identical Triplets
By Taku Komai and Goro Fukuoko..... 233

A Study of the Methods of Breeding the Best Shorthorns
By E. E. Brockelbank and L. M. Winters.... 245

Heritable Characters of Maize
By William H. Eyster..... 251

Radiation-Induced Variation in Cotton
By W. R. Horlacher and D. T. Killough.... 253

Here and There in the Literature..... 243
Nordics, Alpines and Slavs; Two Eugenics Journals; Melanin and Cancer; Schizophrenia; Genes of the Morning Glory; Chromosome Number in Plants.

First Plant Patent Issued..... 262

COMING

Anthropology and Eugenics

Some recent contributions of the science of man to the art and science of human racial betterment.

Zebu-Yak Crosses

Illustrations and pedigree charts showing Mendelian inheritance in a species hybrid in which the females are fertile and the males sterile.

The First Plant Patents

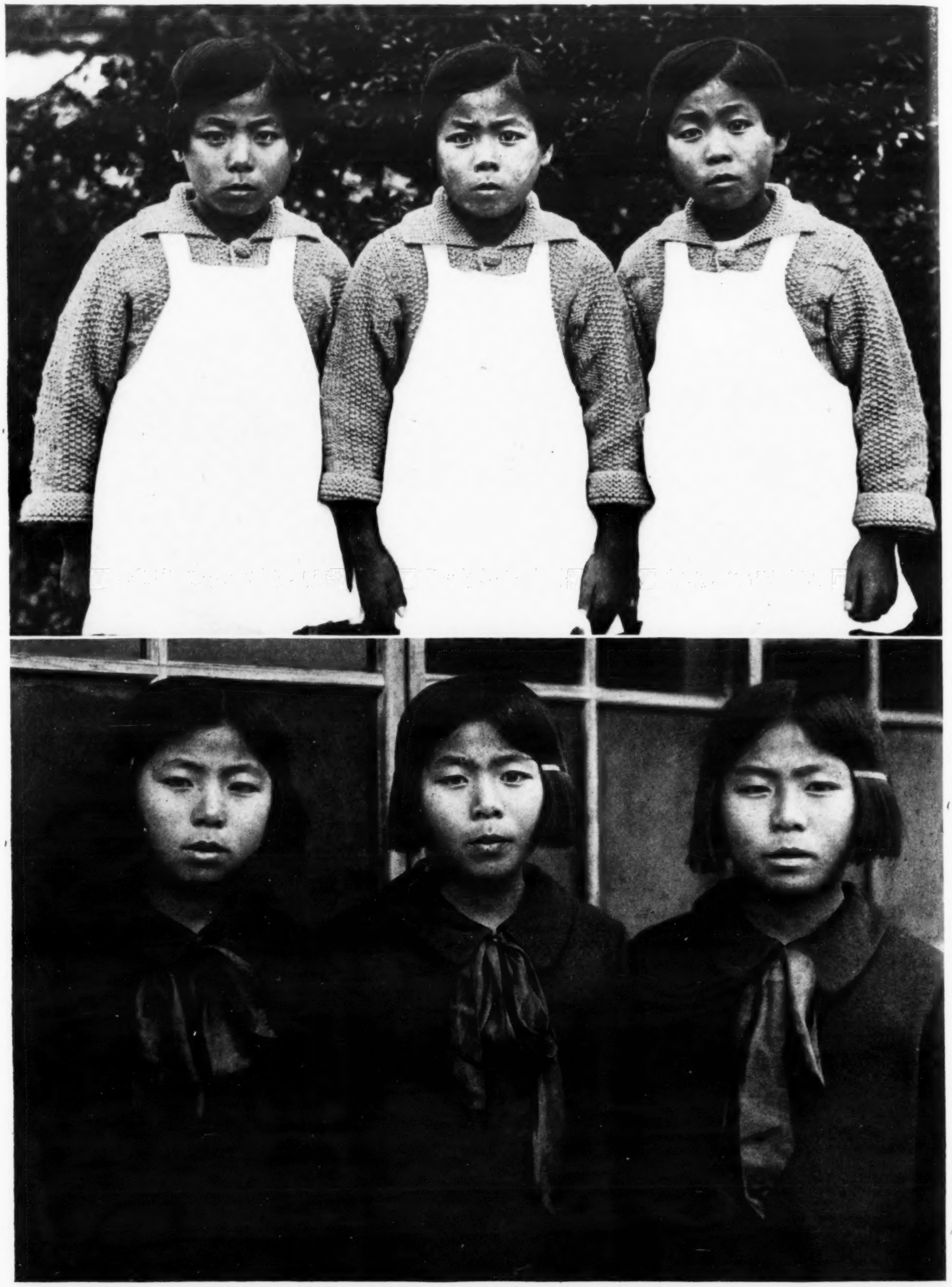
Illustrations and discussion of the genetic and legal phases of the first new plant varieties to be given patent protection.

Origin of Hooded Barley

In the shadow of the Himalayas a queer mutation of barley awns took place a century or so ago that has recurringly interested farmers all over the world, and invariably caused them disappointment.

The JOURNAL OF HEREDITY is published monthly by the AMERICAN GENETIC ASSOCIATION, at 1918-32 Harford Avenue, Baltimore, Md., and Victor Building, Washington, D. C. Address all communications regarding editorial matters and the business management of the Association to Room 306, Victor Building, Washington, D. C. Entered as second-class matter February 24, 1923, at the postoffice at Baltimore, Maryland. Acceptance for mailing at the special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized December 20, 1918. Contents copyrighted 1931 by the American Genetic Association. Unauthorized reproduction of material from THE JOURNAL not permitted. The title "Journal of Heredity" is registered as a trade-mark in the U. S. Patent Office.

$3.50 a Year *Prices of back numbers on application* ***35c. the Copy***



TWO AGES OF THE TRIPLETS

Frontispiece

In all three views (Figure 1) the triplets stand in the same order. The upper view shows them at nine years and three months, and the lower at 11½ years of age. The members of their family can generally tell them apart, but to a stranger they are hopelessly alike. They rank 19th, 21st, and 23rd in their class of 64 girls.

A SET OF DICHORIONIC IDENTICAL TRIPLETS

TAKU KOMAI AND GORÔ FUKUOKO
Kyoto Imperial University, Japan

THE TRIPLETS AT ONE YEAR OF AGE

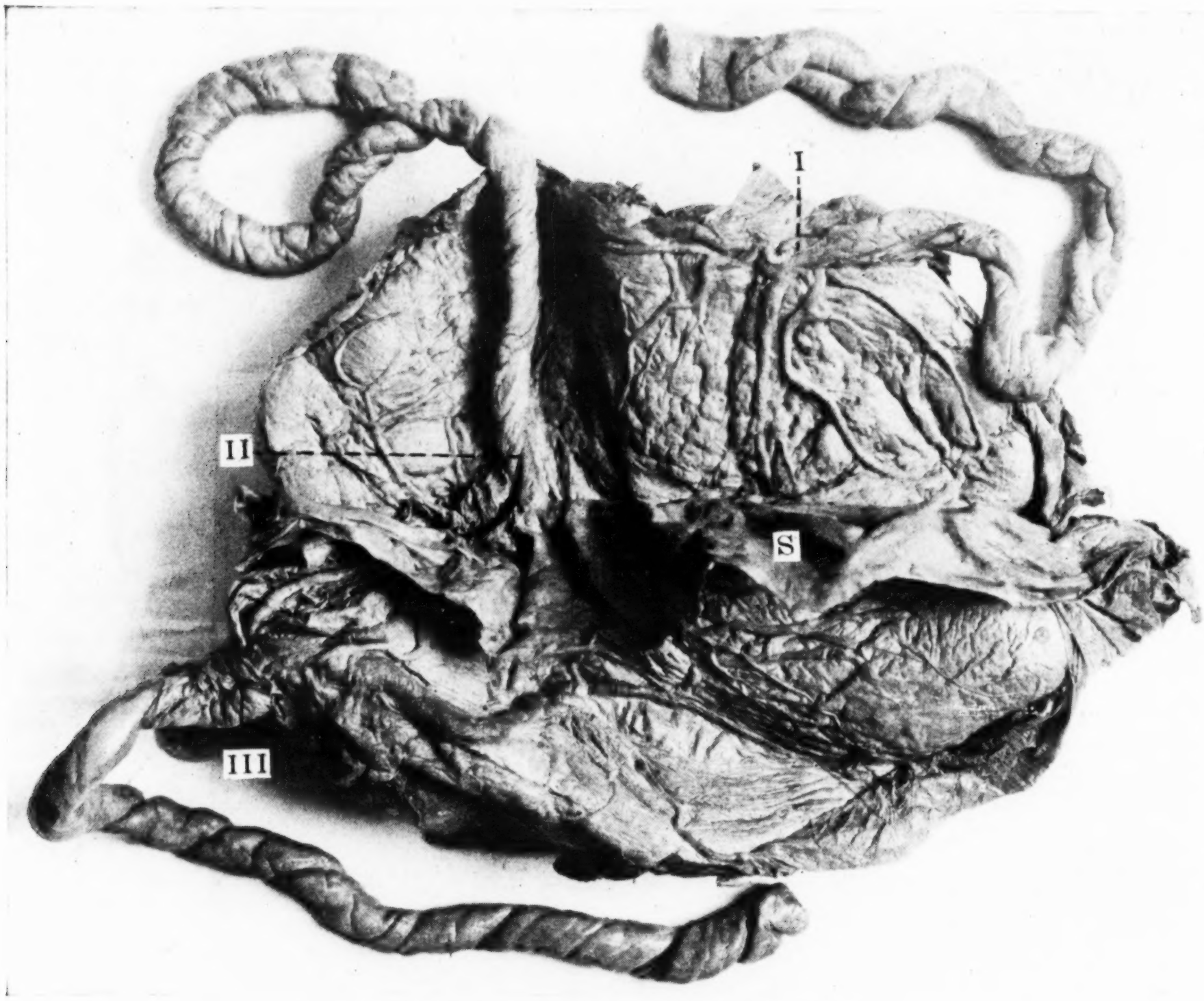
Figure 1

T, K, and *H,* were born August 24, 1919. Their separate birth membranes would at one time have been taken as certain evidence of their being not identical, but several cases of twins have recently been reported in which this conclusion does not seem to hold.

IN a recent number of this JOURNAL was published in an article concerning two sets of presumably monozygotic boy triplets who show a close similarity to one another (Clarke and Revell, 1930). In the *Psychological Clinic* of last year appeared a psychological study of a set of girl triplets, who are, contrary to the former sets, pronouncedly dissimilar, both physically and mentally.[2] Here we propose to report on a set of triplets who are undoubtedly dichorionic, and who still show a marked correspondence, both physically and mentally. The subjects of this study are a set of girl triplets who are living in a suburb of Kobe and attending the same primary school. Their father is in the service of a dockyard company in that port: both he and his wife are apparently quite ordinary persons without any special features, either physical or mental, and, so far as they know, there is no inherited trait of multiple births in either of their ancestral lines.

Birth and Nurture of the Triplets

The triplets, *T, K,* and *H,* are the second of the seven children born to this couple; the first child died very young, and, after the triplets, were born three more girls, *R, M* and *A,* who are all living (Figure 3). The birth of the triplets occurred on August 24th, 1919, when the father was 31 and the mother 27 years old. The doctor who attended the labor is dead now, but the midwife, a woman about 50 years old now, is still pursuing her profession in



PLACENTA OF THE TRIPLETS

Figure 2

I, II, III—Roots of umbilical cords; *S*-Septum, much trimmed so as to show the roots of the umbilical cords in the photograph (2/5 natural size). The septum leaves no doubt that the triplets are dichorionic, so that the strong evidence that they are identical casts much doubt on diagnosis of "identity" or "fraternality" of twins or triplets by examination of the birth membranes.

the city. When interviewed, she remembered the special case very well, and the following statement is based on her verbal and written descriptions of the labor. The pregnancy had been taken for a twin pregnancy by both the doctor and midwife. After pains which lasted nearly three hours, two babies were delivered successively at about noon with an interval of about five minutes. So far the labor was quite normal; the babies had a common chorion which ruptured at the delivery of the first child. Then quite unexpectedly the third child came. This had a caul and came almost automatically through the passage which had been much widened by the previous deliveries. The midwife did not lose time in tearing the caul away; meanwhile, however, the baby was choked to the state of syncope, but recovered by virtue of subsequent treatments. The babies were all in the cephalic presentation and the whole labor was comparatively easy.

To avoid any future confusion, the midwife carefully marked the babies directly after their births, by cutting a tuft of hair from the second-born child *K* and two tufts from the third-born *H*. They were all bottle-fed and brought up in precisely identical surroundings. Before school age, they had not been

very robust, and suffered from tonsilitis, etc., which often came to all at the same time. They entered the primary school at the age of 6 years and 7 months, and since then they have been in the same class. Thus their nurture may be considered to have been perfectly uniform.

Since they entered school they have enjoyed very good health; this is certified by the attendance roll of the school which shows that they were absent from school very seldom, only a day or two in each year. Moreover, all the records in school verify that they have been somewhat superior to the average Japanese girls of the corresponding age, both physically and mentally. At present they stand in stature 12th (*T*), 16th (*K*) and 17th (*H*) respectively, while in school work they rank 19th (*T*), 21st (*H*) and 23rd (*K*) respectively, in their class of 64 girls.

Fetal Membranes

Very fortunately, the after-birth had been preserved by the doctor who attended the labor, and was found in the same maternity hospital, the present proprietor of which had received it, together with other belongings, from that doctor. Except that the placenta is somewhat distorted owing to the small size of the jar, the after-birth is in a rather satisfactory condition and there is no difficulty in making all the necessary examinations of it. The placenta (Figure 2) is broadly oblong in shape, measuring 20 cm. by 18 cm. in diameter. The entire surface is divided into two slightly unequal areas by a membraneous septum which traverses it along nearly the median longitudinal axis (*S*). Three umbilical cords (I-III), each about 1 cm. in diameter, are attached to the placenta, one in the smaller, and two in the larger area. The one found in the smaller area (III) is located at one end of the longitudinal axis near the septum, the second one (II) on the other side of the septum, likewise close to it, at a distance some 6 cm. from the root of the other cord, while the third one (I in the figure) is attached to the other end of the placental margin about 7 cm. from the root of the second cord.

Very clearly the septum is made up of two layers of chorions and a layer of amnion on the other side. The smaller area of the placental surface with one umbilical cord is encircled completely by the remnant of the capsular wall of which the septum forms a part, and lined with the amnion which remains almost intact throughout the entire area. The larger area which is provided with two cords, on the other hand, retains only a small part of the capsular wall around it, and the amniotic lining is nearly gone, although a trace of it may be recognized in the part close to the septum. No septum is found between the roots of the two cords occurring in the larger area, although perhaps there was originally one, consisting only of amnions, which is now missing. Such a feature of the after-birth justifies no other diagnosis than that the triplets were dichorionic. In fact we have shown the after-birth to several competent obstetricians, none of whom hesitated in giving this diagnosis. It must be recalled also that this diagnosis accords well with the midwife's descriptions of the labor stated above. Thus there is no room to doubt that the triplets under consideration were dichorionic at birth.

Physical Features

Notwithstanding the fact that the triplets were dichorionic at birth, they show, physically as well as mentally, such a close similarity to one another as to be interpreted almost unequivocally as of a monozygotic origin. First, in physiognomy they are very similar, although their teacher and their classmates do not confuse them on ordinary occasions. But sometimes even the father takes one of them for another. To all who are not very familiar with them, it is almost hopeless to distinguish them correctly. This is just

what we experience each time we see them. Even those who can distinguish them without much difficulty rarely agree in the opinion of the degree of resemblance and difference among the three; while some people deem the similarity between *T* and *H* to be the closest, others maintain that the resemblance between *K* and *H* is the greatest, and still others find the discrimination of *T* and *K* most difficult.

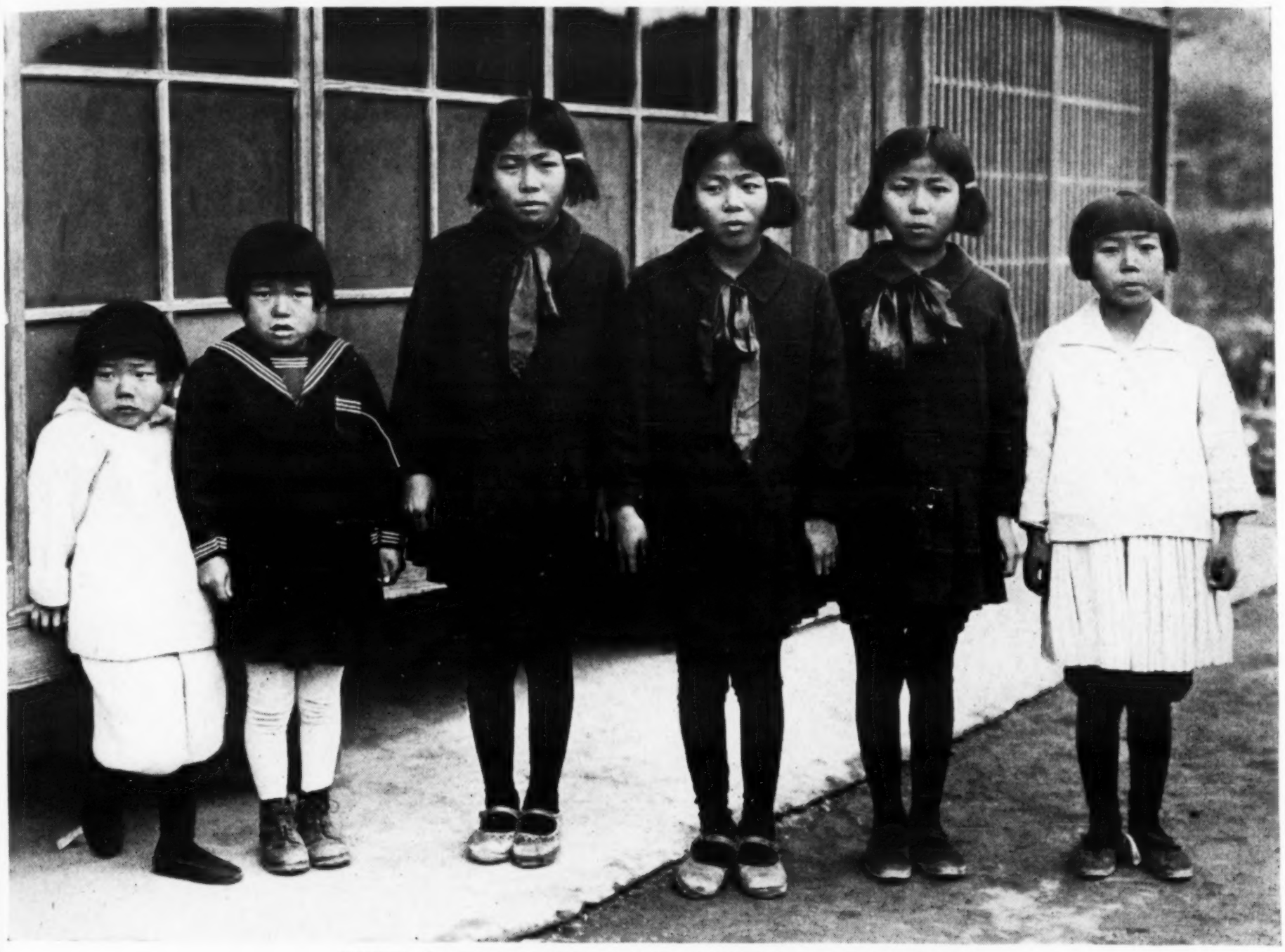
In the color of the iris, hair and skin, they show no difference. The iris is uniformly brown, and is in rather sharp contrast with the other sibs', which is much darker. The eyes, nose, ears and nails also correspond very closely in shape. The triplets' ears are differentiated rather pronouncedly from the other sibs' in that the lobe is fairly large and prominent, whereas it nearly lacks the downward projection in the ears of all of the other sibs. Slight difference, however, may be noted between *K*'s ears and those of the other two, the helix being somewhat broader in the former than in the latter. The nose is also slightly different, so as to give relatively the safest clue to tell the triplets apart: the tip of *K*'s nose is more tilted up, and *H*'s is somewhat broader than the others. The fingernails are very similar, although *K* has slightly shorter nails than the others. The other sibs' nails are much shorter, which seems, however, to be at least partly due to the difference in age. The voices of the triplets are also very much alike, although the mother and sisters can distinguish their voices without seeing them; the class-teacher can tell the voice of *T*, who talks louder, from those of the other two, which he can hardly distinguish from each other. The handwritings are also very similar.

The head-whorl of the triplets is clockwise and located behind the top of the head slightly on the right side in all of them. Of the three other sibs, *R* has a head-whorl nearly identical with the triplets', while *M* and *A* have a clockwise whorl which is elongated in the oblique direction. The saliva of all the members of the family was kindly examined for us by Dr. A. Ogi and he found that they belong to the same group (O). They are all right-handed and kick with the right leg. The clothes of the triplets have always been interchangeable, and the size of gloves and shoes the same. Table I, which has been copied from the school physical-examination records, shows how their stature, weight and girth of chest have always been similar throughout their school age. It is to be noted that these values stand in a rather sharp contrast with those of their younger sister, *R*, in the corresponding ages given in the last column. The other measurements taken by ourselves are given in Table II.

In every measurement we find a remarkable correspondence among the triplets and that there is no sign of differentiation of one member from the rest.

Friction-ridges

The finger-, palm- and sole-prints of the triplets and their sibs, and the finger-and palm-prints of the parents have been obtained and carefully compared. In formulating the finger patterns the method proposed by Bonnevie[1] was preferred to that commonly used in identifying criminals. For palm-patterns, Wilder's formulating scheme[21] was largely followed. The same scheme was adopted for sole-patterns, too, instead of Wilder's scheme especially devised for those patterns, because the former is more suitable to show the differences among the sole-patterns than the latter, where the convenience for classification and cataloging is considered primarily. Table III shows that the finger-patterns of the triplets match very closely and are differentiated sharply from those of the parents and other sibs. This fact can be recognized especially clearly in the quantitative values of the patterns calculated according to Bonnevie's scheme. Whereas the other members of the fam-



THE TRIPLETS AND THEIR SISTERS

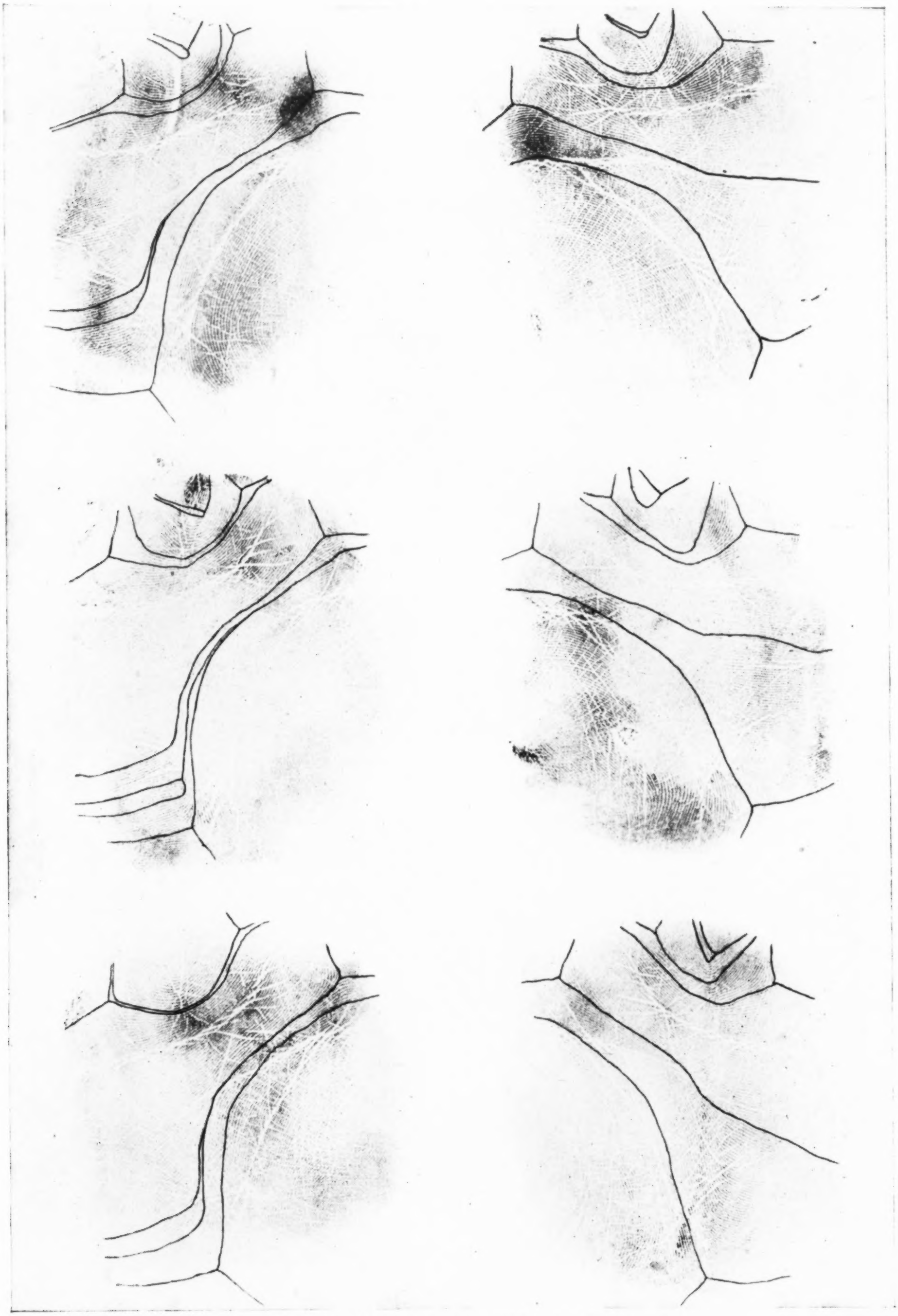
Figure 3

From left to right *A, M, H, K, T,* and *R.* On account of the difference in ages a detailed comparison with the siblings is hardly possible, but a study of the hand and sole prints shows that the triples are sharply differentiated from all other members of the family (see Figures 4 and 5 and Table III).

ily have their characteristic values very different from one another, the triplets have very similar values which can be found only in identical sets of twins or triplets as was shown by Bonnevie[1] and Newman[15,11]. The palm-patterns also exhibit much the same state. This is especially true of the patterns of the right hands of which the triplets have an identical formula. Crucial comparative examinations of the courses of main ridges in Figure 4 will reveal the similarity of hands of the same side more clearly than any description could express. All other sibs have patterns differing greatly from the triplets' and also from one another. The sole-patterns, lastly, reveal an exactly similar situation. As shown in Table IV and in Figure 5, the patterns on the same side match so closely that the similarity between the feet of the same side of different individuals is greater than that between the two feet of the same individual. This kind of similarity found in friction ridges is characteristic of identical pairs of twins, as Newman[13,14] and Komai[9,10] have coincidentally shown some time ago. In short, all the physical features, including physiognomy, bodily measurements, finger-, palm- and sole-patterns, collaborate to establish the monozygosity of the triplets under discussion.

Mental Features

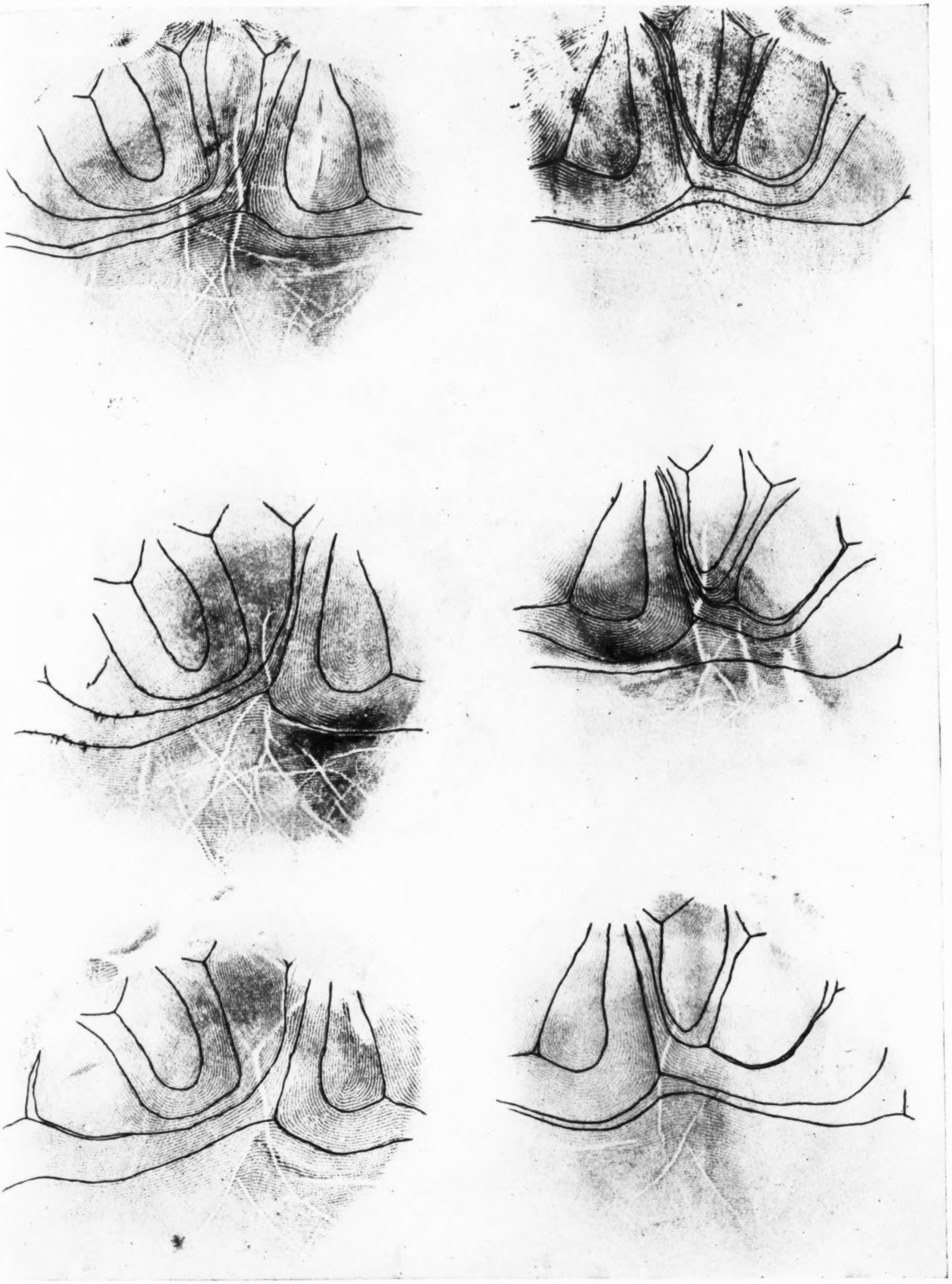
Both the parents and class-teacher agree in the opinion that, in mental characteristics also, the triplets resemble each other very closely. They are



PALM-PATTERNS OF THE TRIPLETS

Figure 4

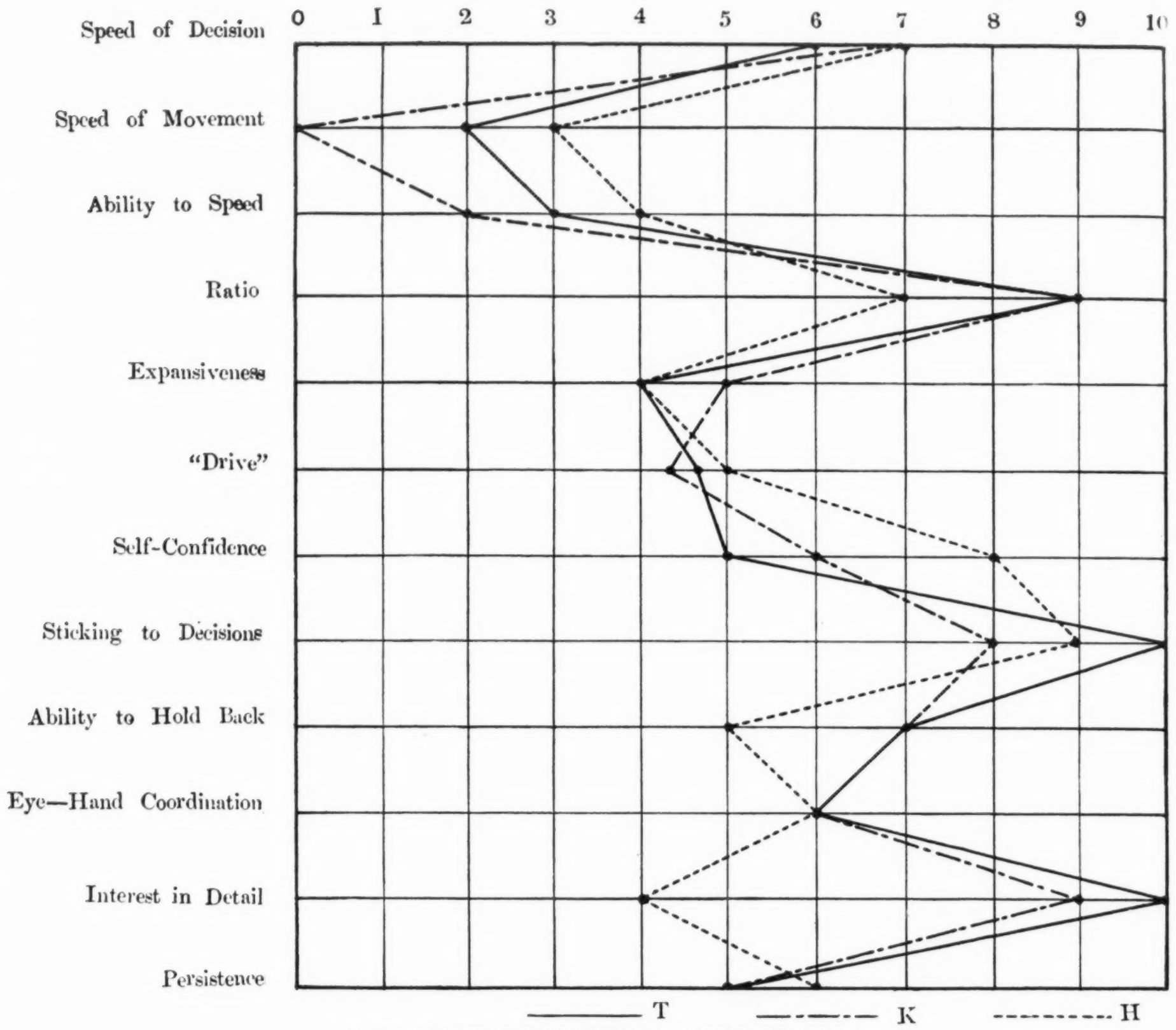
(From top to bottom, *T*, *K* and *H*.) Note the close correspondence of patterns of the hands of the same side. This is the type of resemblance found in the most similar identical twins, that separated so early in development that the embryonic cell-mass had not yet become differentiated.



SOLE-PATTERNS OF THE TRIPLETS

Figure 5

(From top to bottom, *T*, *K* and *H*.) Note, as in the palm-prints, the close correspondence of patterns of the feet of the same side.



WILL-TEMPERAMENT "PROFILES"

Figure 6

While the triplets differ somewhat in some of the characteristics, the "profiles" obtained are of a very similar type—classified as of a positive temperament, non-motile and fairly aggressive.

all of sanguine temperament, clever, expressive and sociable, and have a pretty good stock of common sense for their age, but are rather careless and fickle. They have also much the same likes and dislikes. In school standing they are very nearly the same, belonging to B+ rank, as shown in Table V. As may be clear from this table, they are fairly good in memorizing subjects and comparatively poor in manual work and physical exercise. Thus, generally speaking, they are quick thinkers and slow workers. Their younger sister *R* is very different in school standing, ranking relatively much higher in her class than the triplets.

The parents and class-teacher further agree that *T*, who has been assigned as the "eldest" of the three, is comparatively the most aggressive and takes initiative in many cases, while *H*, the "youngest," is the shyest and most tender-hearted, although it is very hard to tell whether this difference in temperament has anything to do with such an assignment or not.

Psychological Tests

Various sorts of psychological tests have been made by us: (a) drawing the figure of a man; (b) card-sorting; (c) form-board test; (d) tapping with finger; (e) Matsumoto's chopstick test,

and also (d) Kubo's group-intelligence tests A and B; (e) Kirihara's general-intelligence tests and (f) Uhrbrock & Downey—Kirihara's will-and temperament tests. The results are given shown in Tables VI-XIII.

Generally speaking, the scores of the intelligence tests are very similar. Some rather marked difference, however, may be noticed in the scores of the general-intelligence tests (Table XIII). But there is room for suspecting that this difference is, at least to some extent, due to mere chance. The profiles obtained in the will-temprament tests (Table XIV) are also of a similar type, showing that the triplets are of rather positive temperament, belonging to the non-mobile and fairly aggressive type. Scores of tapping and chopstick tests (Tables VIII and IX) show that they are all right-handed and awkward in manual work, which is especially true of *T*.

Remarks

As mentioned above, notwithstanding the fact that the triplets are undisputably dichorionic in origin, there are very strong evidences for their monozygosity in their physical and mental features. Their physiogomy, iris-, skin- and hair-color, bodily measurements, and finger-patterns are very similar, while in the palm- and sole-patterns the correspondence of the same hands or feet of different individuals is closer than that between the two hands or feet of the same individual. For various sorts of psychological tests, the triplets scored very close to one another. All school and physical examination records also signify that they have been very similar, both physically and mentally. The other sibs stand in rather sharp contrast with the triplets in physiognomy, head-index, color of iris, ear-form, finger-, palm-, and sole-patterns, and *R's* school records and physical-examination records are quite different from the triplets. Moreover, there is no feature to differentiate one of the triplets—presumably *H*, who was born with a separate chorion—from the rest, contrary to what could be expected from the state of the after-birth.

In view of this apparent discord between the findings of the state of the after-birth and bodily and mental features, one should wonder whether the diagnosis of zygosity based on the after-birth is wrong, or that that based on physical and psychological features is misleading. In my opinion, the evidences derived from the latter features taken together, are far too strong to be ascribed to mere coincidence (see Muller[12], Siemens[17, 18]) so that the question naturally arises as to whether the diagnosis of zygosity according to the state of the chorion is absolutely reliable or not.

According to certain recent authors, such as Siemens [17, 18, 19], v. Verschuer[20] Curtius[4], and Newman[16], there are cases where this sort of diagnosing method apparently fails, as some twins who were born with separate chorions may show a very close correspondence in many physical features. These cases, however, have usually been considered on *a priori* grounds to be doubtful and have been attributed to a wrong determination of the state of the foetal membranes, or to an improper judgment of the degree of resemblance. The present set of triplets seem to give further strong support to the possibility of the occurrence of such exceptional cases.

Literature Cited

1. Bonnevie, K. 1924. Studies on papillary patterns of human fingers. *Jour. Genetics,* 15: 1-110.

2. Butts, A. L. 1930. Triplets. *Psychol. Clinic* 18 (9): 266-273.

3. Clarke, A. E. and Revell, D. G. 1930. Monozygotic triplets in man. *Jour. Heredity* 21: 147-156.

4. Curtius, F. 1930. Nachgeburtsbefunde bei Zwillinger und Ahnlichkeits-diagnose. *Zeitsch. Induk. Abstamm. Vererb.* 54: 278-279.

5. Dahlberg, G. 1926. Twin Births and Twins from a Hereditary Point of View. Stockholm.

6. Kirihara, H. 1928. General intelligence tests and their norms.—Group mental tests

TABLE I. SCHOOL PHYSICAL-EXAMINATION RECORDS OF THE TRIPLETS AND ONE OF THE SISTERS.

School year(age)		I(6y.9m.)	II(7y.8m.)	III(8y.9m.)	IV(9y.8m.)	V(10y.8m.)
Stature (cm.)	T	107.0	113.0	118.0	122.0	128.0
	K	107.5	112.0	117.0	120.5	126.0
	H	107.0	113.0	117.0	121.0	126.0
	R	112.0 (6y.11m.)	117.5 (7y.10m.)	121.8 (8y.9m.)		
Weight (kgm.)	T	18.0	19.0	21.5	24.0	26.0
	K	17.0	19.0	20.5	23.0	24.0
	H	17.0	19.5	21.2	24.0	25.5
	R	17.0 (6y.11m.)	18.3 (7y.10m.)			
Girth of chest (cm.)	T	54.0	58.0	58.5	60.0	62.0
	K	55.0	56.0	58.5	59.0	63.0
	H	55.2	57.0	60.0	61.0	63.0
	R	51.0 (6y.11m.)	54.0 (7y.10m.)			

TABLE II. PHYSICAL MEASUREMENTS OF THE TRIPLETS AND SIBS (CM.)

	T	K	H	R	M	A
Stature	132.5	132.0	132.2			
Sitting height	71.6	71.7	71.7			
Arm stretch	132.6	130.4	130.5			
Height of middle finger from floor	49.0	49.5	49.5			
Head length	16.7	16.7	16.7	16.1	17.0	17.1
Head breadth	14.8	14.9	14.8	15.1	14.8	14.2
Head index	88.6	89.2	88.6	93.8	87.1	83.0
Face length	12.0	12.0	12.0			
Bizygomatic breadth	11.0	10.9	10.9			
Girth of chest	64.0	62.0	63.5			
Neck circumference	27.0	26.5	27.0			
Wrist circumference	12.6	12.6	12.6			
Middle finger length	16.0	16.0	16.0			
Foot length	19.0	19.0	19.0			
Ear length	4.05	4.0	4.0			
Ear breadth	2.4	2.4	2.4			

TABLE III. FINGER-PATTERN FORMULAE OF THE FAMILY

Finger		I	II	III	IV	V	Quantitative value
Father	L	0-14	0-6	0-9	0-9	0-6	28.5
	R	0-14	4-0	0-9	0-9	0-9	
Mother	L	13-13	2-10	1-11	10-14	10-9	59.5
	R	16-16	6-6	9-4	17-17	11-10	
T	L	0-10	3-0	0-10	0-12	0-3	25.5
	R	0-13	0-0	0-8	0-16	0-6	
K	L	6-12	0-0	0-4	0-8	0-7	25.0
	R	0-11	2-2	0-0	1-11	1-11	
H	L	0-12	2-0	1-0	0-12	0-9	26.5
	R	10-15	0-0	0-3	1-10	0-5	
R	L	0-3	0-6	0-12	0-14	9-12	39.0
	R	0-8	0-1	0-12	9-14	9-14	
M	L	0-17	0-12	0-13	1-14	10-13	50.0
	R	9-16	0-8	0-15	8-14	9-15	
A	L	0-8	0-0	0-1	0-3	0-2	16.5
	R	0-12	0-4	0-5	0-2	1-2	

TABLE IV. PALM- AND SOLE-PATTERN FORMULAE OF THE FAMILY.

		Palm pattern	Sole pattern
Father	L	7-5-5-3-c / 12	
	R	7-5-5-3-c / 10	
Mother	L	9-0-5-5-c / 16	
	R	9-0-5-5-c / 16	
T	L	9-7-5-3-c / 28	11-9-7-5-13 / d*
	R	11-9-7-3-c / 30	15-13-11-9-13 / dd**
K	L	11-7-7-3-c / 12	12-9-7-6-13 / d
	R	11-9-7-3-c / 30	15-13-13-11-13 / dd
H	L	11-0-7-3-c / 32	12-9-7-6-13 / d
	R	11-9-7-3-c / 30	15-4-4-11-13 / dd
R	L	10-9-6-2-c / 14	10-9-7-2-13 / d
	R	11-11-9-5-c / 14	15-10-8-7-13 / dd
M	L	9-7-5-4-c / 12	15-9-9-4-13 / dd
	R	9-7-5-3-c / 18	15-9-7-7-13 / d
A	L	11-7-9-5-c / 26	2-9-7-7-15 / d
	R	11-9-7-5-c / 14	15-4-13-11-15 / d

*d upper plantar delta present
**dd upper and lower plantar deltas present.

TABLE V. SCHOOL MARKS.

School year		I	II	III	IV	V
Memorizing subjects*	T	91	92	91	85	88
	K	90	92	92	86	86
	H	91	91	90	88	90
Arithmetic	T	88	89	87	66	78
	K	82	84	85	67	68
	H	91	86	90	70	68
Manual and physical subjects**	T	80	80	67	69	72
	K	80	76	66	67	72
	H	86	79	68	70	73

* Including language, history, geography, science and ethics
**Including penmanship, drawing, sewing, handicraft and gymnastics.

TABLE VI. SCORES OF FORM-BOARD TEST.

T	K	H
25	20	27

TABLE VII. SCORES OF CARD-SORTING TEST (MEAN OF 6 TRIALS).

T	K	H
28.1	29.2	27.1

TABLE VIII. SCORES OF TAPPING TEST (MEAN OF 6 TRIALS, EACH 30 SECONDS).

	T	K	H
Right hand	103.1	142.3	131.8
Left hand	90.8	118.7	116.3

TABLE IX. SCORES OF CHOPSTICK TEST (TOTAL BEANS PICKED UP IN 7 TRIALS EACH IN 30 SECONDS).

	T	K	H
Right hand	106	122	123
Left hand	17	40	46

TABLE X. SCORES OF INTELLIGENCE TEST BY MEANS OF DRAWING (GOODENOUGH-KIRIHARA'S SCHEME).

	T	K	H
Score	39	38	39
Mental age	12	11.6	12

TABLE XI. SCORES OF KUBO'S GROUP INTELLIGENCE TESTS SCALE A, (NATIONAL INTELLIGENCE TESTS, SCALE A, FORM 1 & 2, REVISED SO AS TO SUIT JAPANESE CHILDREN).

	T	K	H
Test 1. (Arithmetical reasoning)	10	6	10
2. (Sentence completion)	26	22	24
3. (Logical selection)	27	29	21
4. (Synonym-antonym)	24	24	31
5. (Symbol-digit)	21	20.7	20.1
Total	108	101.7	106.1

TABLE XII. SCORES OF KUBO'S GROUP INTELLIGENCE TESTS, SCALE B, (NATIONAL INTELLIGENCE TESTS, SCALE B, FORM 1 & 2, REVISED SO AS TO SUIT JAPANESE CHILDREN).

	T	K	H
Test 1. (Computation)	28	28	28
2. (Information)	24	20	23
3. (Vocabulary)	13	17	14
4. (Analogies)	25	16	22
5. (Comparison)	17	21	23
Total	107	102	110

TABLE XIII. SCORES OF KIRIHARA'S GENERAL INTELLIGENCE TESTS (B).

	T	K	H
Test 1. (Completion) 2. (Analogy)	17	20	13
3. (Recognition)	15	10	11
4. (Rybakow figure)	9	5	2
Total	41	35	26

for juvenile and adult (Japanese). *Jour. Sci. Labour.* 5: 749-999.

7. ———— 1930. Kirihara's revision of Downey and Uhrbrock's non-verbal will-temperament test—Its method and norm for the Japanese (Japanese). *Jour. Sci. Labour* 7: 445-534.

8. ———— 1930. Measurements of intelligence of infants by drawing (Japanese). *Trans. Institute f. Child Study.* 13: 777-818.

9. KOMAI, T. 1927. A criterion for disdinguishing identical twins from fraternal twins. *Science.* N. S. 65: 280.

10. ———— 1928. Criteria for distinguishing identical and fraternal twins. *Quart. Rev. Biol.* 3: 408-418.

11. KUBO, Y. 1923. The group intelligence tests of school boys and girls aged from 8 to 25 years (Japanese). *Trans. Institut. f. Child Study* 7: 1-92.

12. MULLER, H. J. 1925. Mental traits and heredity. *Jour. Heredity* 16: 433-455.

13. NEWMAN, H. H. 1928 *a.* Studies of human twins I. Methods of diagnosing monozygotic and dizygotic twins. *Biol. Bull.* 55: 283-297.

14. ———— 1928 *b.* II. Asymmetry reversal, or mirror imaging in identical twins. *Biol. Bull.* 55: 2981315.

15. ———— 1930. The finger prints of twins. *Jour. Genetics* 23: 417-446, pls. 17-18.

16. ———— 1931. Palm Prints in Twins. *Journal of Heredity* 22:41-49.

17. SIEMENS, H. W. 1924 *a.* Uber die Eineiigkeitsdiagnose der Zwillinge aus den Eihäuten und dem dermatologischen Befund. *Zeitsch. Induk. Abstamm u. Vererb.* 37: 122-124.

18. ———— 1925. Die Diagnose der Eineiigkeit in geburtshilflicher und in dermatologischer Betrachtung. *Arch. f. Gynaekol.* 126: 623-643.

19. ———— 1927. The diagnosis of identity in twins. *Jour. Heredity* 18: 201-209.

20. v. VERSCHUER, O. 1927. Die vererbungsbiologische Zwillingsforschung Ihre biologischen Grundlagen. *Ergebn. d. Inn. Medizin u. Kinderheilk.* 31: 35-120.

21. WILDER, H. H. AND WENTWORTH, B. 1918. Personal Identification. Boston.

Here and There In the Literature

Nordics, Alpines and Slavs

GRIFFITH TAYLOR of Chicago University discusses in the JOURNAL OF SOCIOLOGY for July the Nordic and Alpine races and their kin. Taylor believes that the Nordics are dying out and that his racial pets, the Alpines, are well able to replace them. In fact he believes that any race except the Negro is equal to any other race, and as a corollary, that eugenics depends on selection of the superior strains within the race or from several races, rather than in racial selection.

Rudolph Broda (Antioch College) discusses the revival of Nationalities in the Soviet Union. Since the revolution there has been remarkable, almost explosive, development of the various groups that make up Russia. Twenty-seven nationalities are listed in the census of 1926. The present arrangement, of a centralized government to control the major political and economic problems, seems to have overcome the centrifugal tendencies of these groups, at least for the time being.

Two other articles, on "Social Factors and Sex-ratio at Birth" and on "Age at Marriage and Social Class" deserve more extended discussion, it is hoped in a later issue.

Two Eugenics Journals

TWO eugenics journals have recently appeared—one in Japan and one in Italy. The Japanese Journal *Eugenico* is the monthly organ of the Japanese Eugenics Institute. Being in Japanese, we can only detect an occasional scientific name and a discussion of blood groups, sprinkled with *A's, B's, O's* and *AB's. Genesis,* published quarterly by the Italian Federation of Eugenics is devoted to studies of sex, demography and eugenics. The current number contains articles on fecundity and sterility in consanguineous marriages, eugenics in Latin America, the chances for marriage in Holland since the World War, but much of the material is medical in nature rather than strictly eugenic.

Melanin and Cancer

RECENT numbers of the *American Journal* of Cancer contain two articles by Myron Gordon on the very interesting discoveries with regard to the relations of the color-patterns of platy fish to the development of malignant tumors. As explained in a recent number of our JOURNAL, there are two kinds of pigment cells, producing stipples (micromelanophores) and spots (macromelanophores). In genus hybrids with another Mexican fish (Xiphophora) the micromelomophores behave normally, but the macromelanophores develop abnormally and eventually produce typical cancerous growths (melamomas). The study of these hybrids offers an interesting field to determine why these cells behave differently, and why one kind, in a new environment leads to malignancy, while the other does not.

Schizophrenia

IN the *Medical Times* for July is an interesting discussion of Schizophrenia (Dementia Praecox) by Dr. J. F. W. Meagher. There are thirty or forty thousand new cases of this disease every year in the United States. Since the disease runs a long course it furnishes a considerable proportion of the inmates of asylums for the insane. Psychiatrists are not agreed on the causes of the affliction, but that heredity is an important factor can hardly be doubted, especially in view of the fact that several cases have been recorded of identical twins being almost simultaneously affected.* Certainly the inheritance is not as simple as that of Huntington's Chorea, and the disease manifests itself in a variety of forms, due, one might imagine, to a variety of genes. Some of the patients do not "dement," and some become affected at an advanced age, so that the older name has given place generally to the more complicated and descriptive term signifying "split personality." The disease is a good example of the increasingly important concept that the development of any character is the resultant of heredity and environment. A certain hereditary type reacting to unfavorable factors in the environment produces a given resultant. The fact that the prospects for recovery are on the average not good is further evidence that schizophrenics are not entirely the product of their environment. The endocrines have been accused of being the cause of the disease, but endocrine thereby has proved disappointing.

Genes of the Morning Glory

The Japanese morning glory (*Phabitis nil*) has been grown in the Orient for 2,200 years. It is found now only under cultivation. A list of the genes known in this species is given in *Genetica* 12: 297-307, by Yoshutaha Imai, who has done much to increase our knowledge of the genetics of this plant. The list comprises 111 genes of which only fifteen are dominant. The more striking effects of some of the genes are illustrated with photographs and drawings.

Chromosome Number in Plants

IN *Genetica,* Vol. 12, Nos. 2-3, Professor L. O. Gaiser gives a 100-page supplement to his earlier list of the chromosome number in Angiosperms. When it is considered that the article deals only with material published in 1929, and some in 1928, the amount of work being done on chromosome number begins to be realized. An 11-page bibliography on which the list is based refers to about 220 papers. Sixty pages are devoted to dicolyledonous plants, and thirty to the monocots. As a source of information on chromosome number in plants the list is invaluable.

*Parker, J. H. Twins with Dementia Praecox. *Journal of Heredity* 17:137-143. 1926.

A STUDY OF THE METHODS OF BREEDING THE BEST SHORTHORNS

In the United States During the Period 1920-1928

E. E. Brockelbank and L. M. Winters*
University of Minnesota

MANY studies have been made as to methods of breed and herd building. In general they have brought out that inbreeding, crossbreeding (including outcrossing) and selection have all been used. Just how effective each has been or what any one alone could have accomplished has never been proven.

Genetic studies indicate that we have a right to expect great sires and great dams as the result of continued inbreeding and that outcrossing should give us our best show animals.

This study was undertaken in an attempt to find out, how, during the period 1920 to 1928, the best Shorthorns in the United States have been produced. Have they been produced by inbreeding, outcrossing, or phenotypic selection?

McPhee and Wright[1] made a rather complete genetic analysis of the Shorthorn breed, taking as a base the period in Shorthorn history just before Favourite was calved in 1793, as he is considered to have been one of the main progenitors of the breed. Using Wright's formula[3] to measure the inbreeding they report a rise from zero in 1790 to 17 per cent inbreeding in 1810. By 1825 the inbreeding had risen to 20 per cent. From that time until 1920 the inbreeding coefficient had changed very little, then being 26 per cent. The sharp increase in inbreeding reached in the period 1810-1825 was no doubt due to the Colling Brothers' famous herds. This inbreeding coefficient of 26 per cent for the breed as a whole in 1920 means that the breed is 26 per cent more homozygous than the original stock, due to inbreeding alone. Selection may also have increased the homozygosity. Wright[4] made an analysis of the Duchess Shorthorns bred by Mr. Bates. Their coefficient of inbreeding was about 40 per cent.

Smith[2], using Wright's coefficient, found that the coefficient of inbreeding of the Clydesdale breed of horses rose from zero in 1865 to only 7 per cent in 1925. He states that selection and line breeding have played a very important part in the fixation of typical Clydesdale characters which are transmitted without much variation.

A previous study made by the junior author, a comparison of the inbreeding of twenty leading Hereford sires of the previous five years as judged by the show winnings of their progeny with twenty random picked Hereford sires, shows these leading sires to have an average coefficient of inbreeding of 3.07% whereas random picked sires had an average coefficient of 2.45%. These coefficients were derived from five generation pedigrees. A summary of these results is shown in Table I. Very little more inbreeding was resorted to to produce the leading sires. Selection must have been the bigger factor. Opportunity very likely was another factor, but opportunity is very difficult to measure. The presence of show winners in the pedigree is much higher for the leading sires, as shown by the same Table.

Material, Methods, and Data

A study involving an analysis of pedigrees where inbreeding, outcrossing

* Published as Paper No. 954, Minnesota Journal Series, with the approval of the Dean and Director of the Minnesota Experiment Station.

and phenotypic selection is to be considered must of necessity include some method of measuring inbreeding. A number of methods have been put forward, but that advanced by Wright[4] has been used, as it satisfies most completely the requirements of a coefficient of inbreeding which Wright states are as follows: "An inbreeding coefficient to be of most value should measure as directly as possible the effects to be expected on the average from the system of mating in a given pedigree. . . . For a natural coefficient of inbreeding we want a scale which runs from 0 to 1 while the precentage homozygosis is running from 50 to 100 per cent."

A list of first and second prize winners from the International Live Stock Exposition for the years 1900 to 1928 was compiled. Using the International Live Stock Exposition as a criterion of the highest perfection attained by the Shorthorn breed in the United States, one hundred animals were selected from the above list to be known as the Present Day Show Winners. This list includes the first and second prize winners in the breeding classes beginning with the 1928 Show and going back to part of the 1924 winners. It was necessary to reject a few animals which were recorded in the Canadian herd book as their pedigrees could not be traced conveniently.

A second list of one hundred animals, known as the Random Selected Individuals, was chosen at random from the volumes of the herd book in which the Present Day Show Winners are recorded. Males and females were chosen alternately and Polled Shorthorns were rejected.

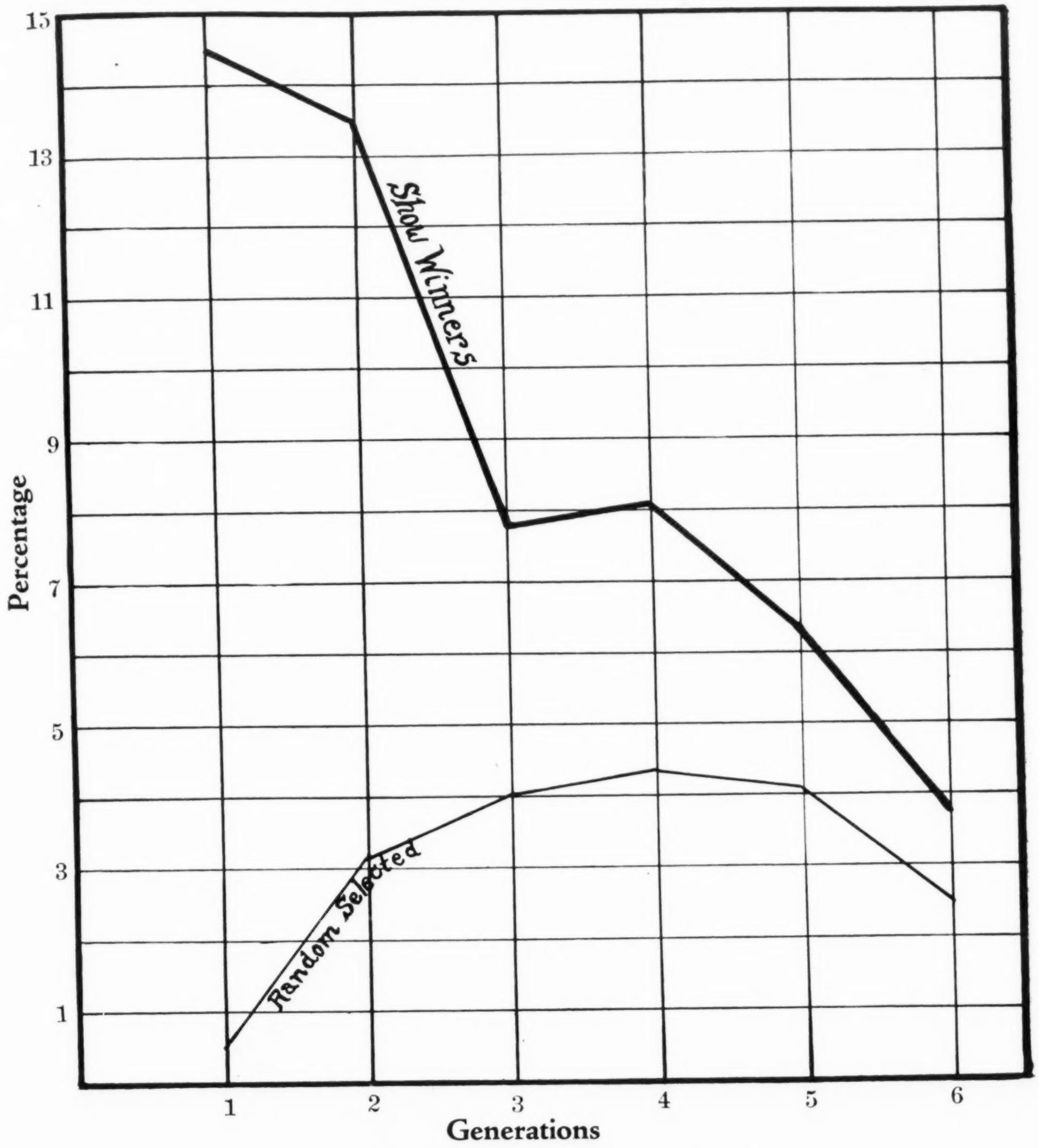
The pedigrees of these two hundred animals were tabulated to the sixth generation in order to make as complete a study of the breeding of these individuals as seemed necessary.

Using Wright's coefficient, a comparison of the inbreeding of the two groups was made. The average coefficient of inbreeding for the Present Day Show Winners is 2.064%, while that of the Random Selected Individuals is 1.028%, or slightly less than one-half as much. McPhee and Wright[1] show that the coefficient of inbreeding for twenty leading sires, as brought forward by Malin, differed very slightly in inbreeding from the average of the breed. McPhee and Wright also show that the inbreeding for the breed as a whole for the period 1790 to 1920 was 26% and that most of this inbreeding occurred during the formative period, 1800 to 1820. Since 1900 there has been a very slight rise in inbreeding. The results of this study show a similar slight rise in inbreeding since 1920. It would seem, then, that the systems of mating practiced by the Shorthorn breeders in the production of the Present Day Show Winners has not led to inbreeding to any appreciable extent, with its accompanying homozygosity.

Table I gives a summary of a study made by Winters of Hereford sires. While the results are not directly comparable to those in this study, in the main the results are of the same general trend. The percentage of inbreeding is 3.07 for the leading sires and 2.45 for the random picked sires, which is higher in both cases than was found in this Shorthorn study. It can also be said that, according to this study, inbreeding was not a big factor in the production of recent leading Hereford sires.

It must be remembered that the Present Day Show Winners may be and likely are more homozygous for desirable characters, due to another factor, namely, selection. It is rather difficult to measure accurately the effects of selection upon homozygosity, but an indication of its influence may be had from the answer to the question—Do show winners produce show winners?

To answer this question the ancestry of the Present Day Show Winners and the Random Selected Individuals for six generations was checked for the presence of animals that won first or



SHOW-WINNERS PRODUCE SHOW-WINNERS

Figure 7

Graph showing the perecentage of prominent prize winners in the ancestry of present day show winners and in the ancestry of individuals selected at random from the herd book. This graph indicates that breeders of shorthorn show winners are depending on phenotypic selection rather than on inbreeding.

second at the International Live Stock Exposition during 1900-1928.

Table II gives a summary of these results, generation by generation, which is illustrated in Figure 7. A comparison shows that the Present Day Show Winners have 14 per cent more show winners in the first generation than have the Random Selected Individuals, and slightly more than 10 per cent in the second generation. There is a gradual narrowing of this

margin, which in the sixth generation amounts to only 1.37 per cent. The presence of more show winners in the pedigrees of the Present Day Show Winners than in the Random Selected Individuals would lead to the conclusion that phenotypic selection has definitely been a factor in the production of show winners, that the best phenotypically have been mated to the best and that breeders have been placing more reliance on this system of breeding than on the practice of inbreeding, with its doubtful immediate consequences. This would also indicate that the Present Day Show Winners are more homozygous than the Random Selected Individuals and since the inbreeding differed little, selection must have been a factor in increasing homozygosity.

In the use of the term "selection" it is recognized that the more constructive breeders practice selection in its broadest sense, i.e., they take into account breeding performance and pedigree as well as phenotype. In a study of this kind it is impossible to measure the influence breeding performance and pedigree have had on selection, hence this study has been confined to phenotype, on which one can use an arbitrary measure.

The above results agree in the main with the findings of Winters, given in Table I, where the percentage of show winners in the first generation of the twenty leading Hereford sires was 95, while there were no show winners in the first generation in the random sires. In the second generation there were 75 per cent more winners and in the fifth generation 19 per cent more show winners in the leading sire pedigrees than in the random sire pedigrees. In all cases the number of show winners is higher than was found in the present study. This is probably due to the fact that the leading sires were picked because they were the best sires.

As already stated, genetic studies indicate that we have a right to expect great sires and great dams by the practice of inbreeding and that outcrossing should give us the best show animals. The inbreeding of the individual show winners has been compared with the average inbreeding of the sire and dam of the individual. Out of one hundred individuals, in eighteen cases the inbreeding is equal, in thirty-six cases the individual show winner has more inbreeding than the average of the sire and dam, and in forty-six cases the average inbreeding of the sires and dams is higher than that of the individual show winner. The difference in inbreeding in all cases is rather small. Arising from this it can be stated that Shorthorn breeders have not been making outcrosses for the production of show winners.

The most important point in Table III is the fact that the Present Day Show Winners have a higher coefficient of inbreeding than the average of their sires and dams. The amount of inbreeding is small but, as has already been stated, it does demonstrate that outcrossing has not been responsible for the production of the show winners in this study. Another point is that the additional coefficient of inbreeding due to the sixth generation is very small, being .001276. This would indicate that five generation pedigrees would, in this study, have given practically the same coefficient of inbreeding as did the six generation pedigrees. This Table also shows that the average inbreeding of the sires of the Present Day Show Winners and of the dams of the Present Day Show Winners have approximately an equal amount of inbreeding, which is small.

Summary

Inbreeding has not been a factor in the production of show winning Shorthorns at the International Livestock Exposition during the period 1924-1928.

Shorthorn breeders have not prac-

ticed outcrossing in the production of show winners.

Show winners do tend to produce show winners. This is evident that Shorthorn breeders have been making assortive matings.

From the small amount of inbreeding practiced in the production of show winners and from the fact that show winners produce show winners it would appear that Shorthorn breeders have been producing show winners by selection in the broad sense of the term, considering individuality, breeding performance and pedigree.

This does not prove, however, that inbreeding could not be used effectively for the production of breeding animals and outcrossing for the production of show animals.

This study indicates that the percentage of inbreeding for the breed as a whole is increasing gradually.

Literature Cited

1. McPhee, Hugh C. and Wright, Sewall. 1925. Mendelian Analysis of the Pure Breeds of Livestock. III. The Shorthorns. *Jour. Her.* 16:205-215.

2. Smith, A. D. Buchanan. 1926. Inbreeding in Cattle and Horses. *The Eugenics Review*, 18:189-204.

3. Wright, Sewall. 1922. Coefficients of Inbreeding and Relationship. *Amer. Nat.*, 56:330-338.

4. ———. 1923. Mendelian Analysis of the Pure Breeds of Livestock. II. The Duchess Family of Shorthorns as Bred by Thomas Bates. *Jour. Her.* 14:405-422.

TABLE I. Summary of Inbreeding and Show Winners on Five Generation Pedigrees of 20 Leading Hereford Sires and 20 Random Sires

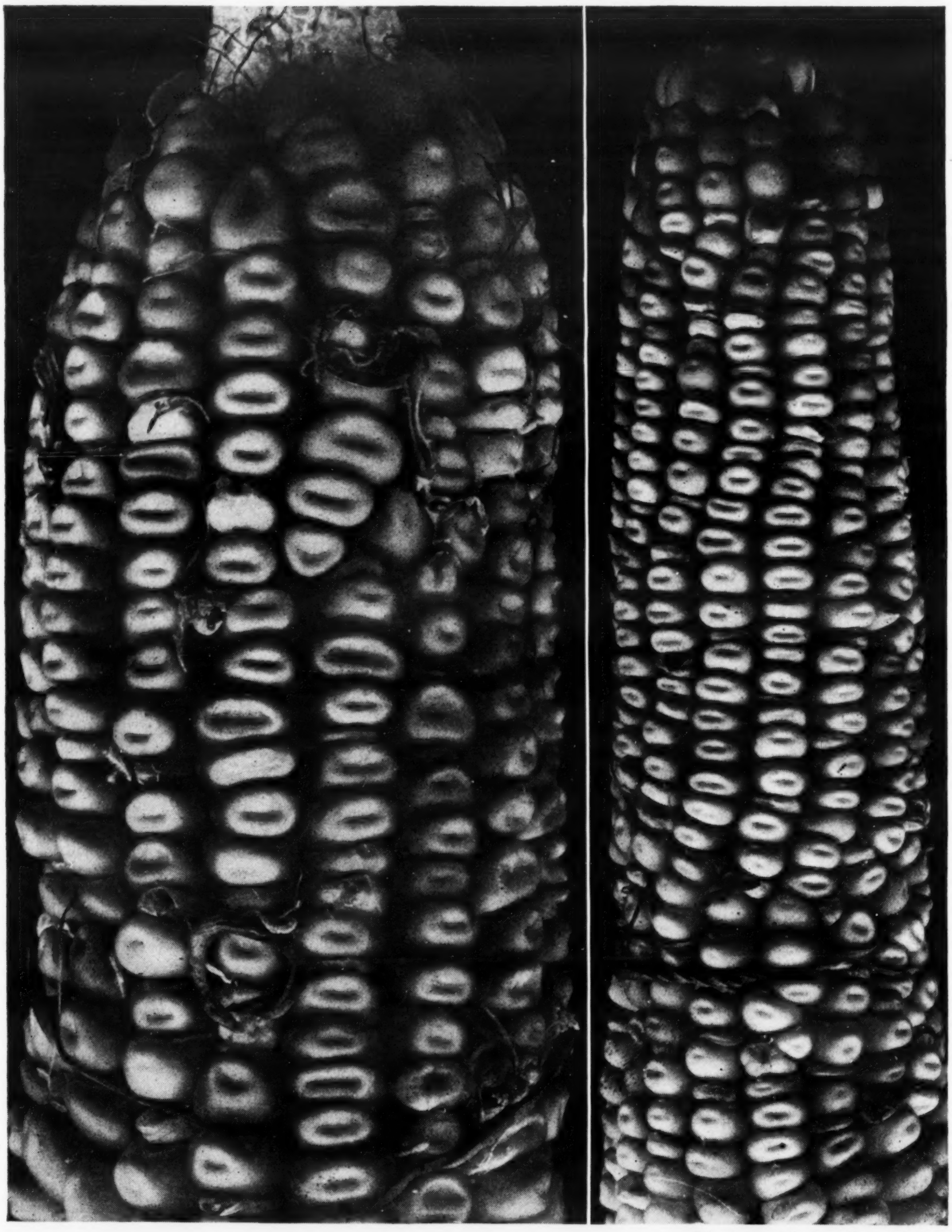
SHOW WINNERS IN PEDIGREES						
	Leading Sires		Random Sires		Total Possible	
Generation	Actual No.	Percentage	Actual No.	Percentage	No.	Percentage
1	19	95	0	0	20	100
2	38	95	8	20	40	100
3	67	84	31	39	80	100
4	136	85	91	57	160	100
5	273	85	211	66	320	100
Inbreeding coefficient, per cent.		3.07		2.45		

TABLE II. The Number and Percentage of First and Second Prize Winners in the Ancestry of the Present Day Show Winners and the Random Selected Individuals

	Present Day Show Winners		Random Selected Individuals		Total Possible	
Generation	Actual No.	Percentage	Actual No.	Percentage	No.	Percentage
1	29	14.5	1	.5	200	100
2	54	13.5	13	3.25	400	100
3	62	7.75	32	4.0	800	100
4	129	8.06	74	4.62	1600	100
5	203	6.34	142	4.43	3200	100
6	248	3.87	160	2.50	6400	100

TABLE III. A Summary of the Average Inbreeding of 100 Present Day Show Winners for Five and Six Generations and the Average Inbreeding of their Sires and Dams for Five Generations

Present Day Show Winners		Sire	Sire and Dam	Dam
6 Gen.	5 Gen.	5 Gen.	Average	5 Gen.
.020636	.01936	.00957	.008779	.008013



Photograph by the Author

TWO TYPES OF REDUCED ENDOSPERM

Figure 8

An ear segregating an F_2 progeny of normal and reduced endosperm$_1$ kernels. Note that most of the reduced endosperm$_1$ kernels produced viviparous sporophytes because of the close linkage between these characters. The genes for both these reduced endosperm characters are located in the same chromosome, but that for *re*$_2$ is closer to the *vp*$_2$ gene than is *re*$_1$.

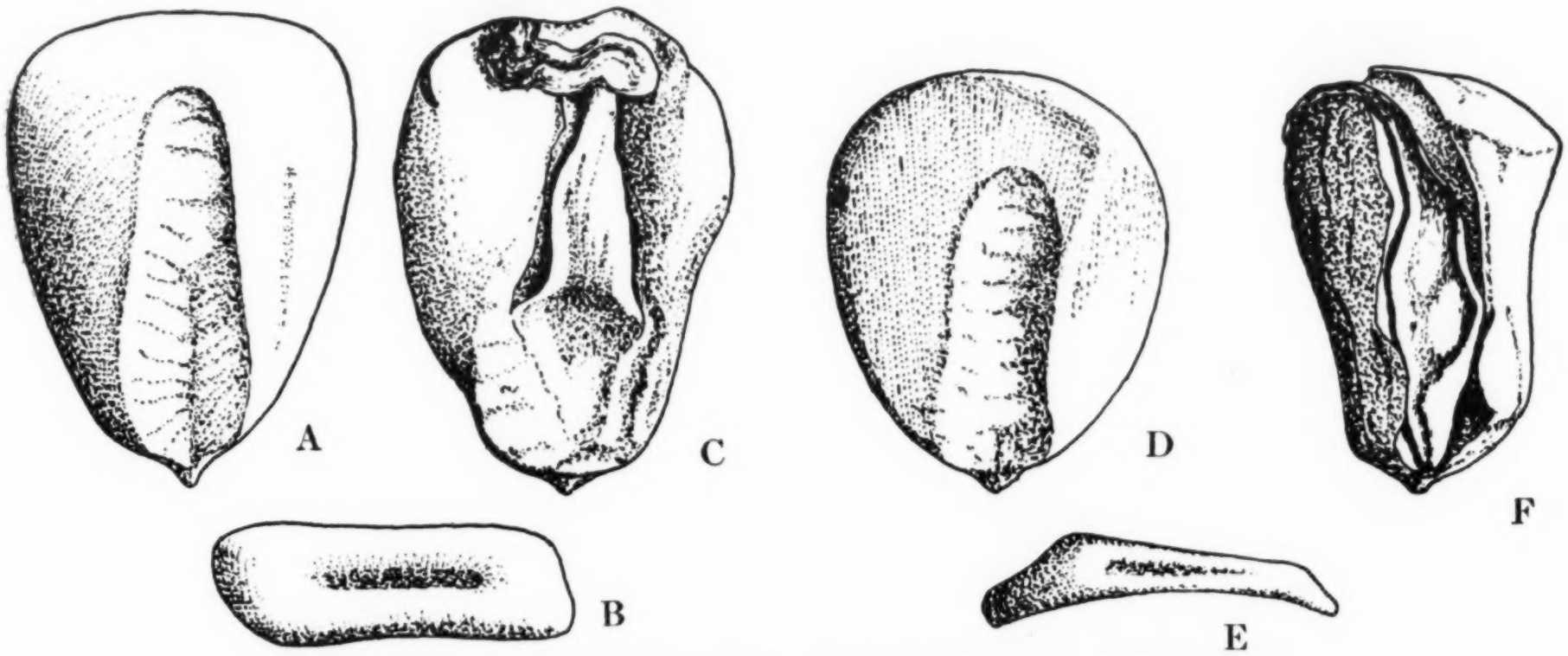
Figure 9

An ear segregating an F_2 progeny of normal and reduced endosperm$_2$ kernels. Note that practically all of the kernels with reduced endosperm have viviparous embryos due to the very close linkage between *re*$_2$ *vp*$_2$.

HERITABLE CHARACTERS OF MAIZE

XLII—Reduced Endosperm*

WILLIAM H. EYSTER



NORMAL AND REDUCED ENDOSPERM$_1$ KERNELS

Figure 10

A, a kernel with normal endosperm and dormant embryo; *B*, distal end of kernel having normal endosperm; *C*, a kernel with normal endosperm and viviparous embryo; *D*, a kernel with reduced endosperm and dormant embryo; *E*, distal end of kernel with reduced endosperm; *F*, a kernel with reduced endosperm and viviparous embryo. Drawings by Miriam Groner.

A LARGE number of endosperm deficiencies have been described in the literature under the general title of "Defective Endosperm." The kinds of variations that have been included under this general title are so large in number and so different in fundamental nature that the writer is using the name *Reduced Endosperm* for a genetic variation in kernels of maize which might be included under defective endosperm.

Kernels with reduced endosperm and, therefore, of correspondingly smaller size have occurred in many of my pedigrees and are produced, apparently, by a large number of genes. In the present paper descriptions and illustrations will be given of kernels with reduced endosperm which are the expressions of genes having their loci in choromosome VIII.

Reduced Endosperm$_1$

Reduced endosperm$_1$ kernels are very much smaller than the normal kernels of the same ears so that they can be distinguished easily. The general size of these kernels may be seen from the illustration in Figure 8. Usually they are shorter than normal kernels, and are much flattened as shown by the drawings in Figure 10. In extreme cases the endosperm may be almost completely absent, though ordinarily the kernels with reduced endosperm$_1$ vary from one-fourth to one-half the size of their normal sibs.

Reduced endosperm$_1$ is inherited as a simple Mendelian recessive character. A summary of nine F_2 progenies is given in Table I.

This shows a deviation of 30 ± 16.4 from the expected frequencies.

The gene for reduced endosperm$_1$, Re_1, has its locus in chromosome VIII at a distance of approximately 15.5 crossover units from the gene Vp_2 which inhibits dormancy of the embryo in the seed stage of its development.

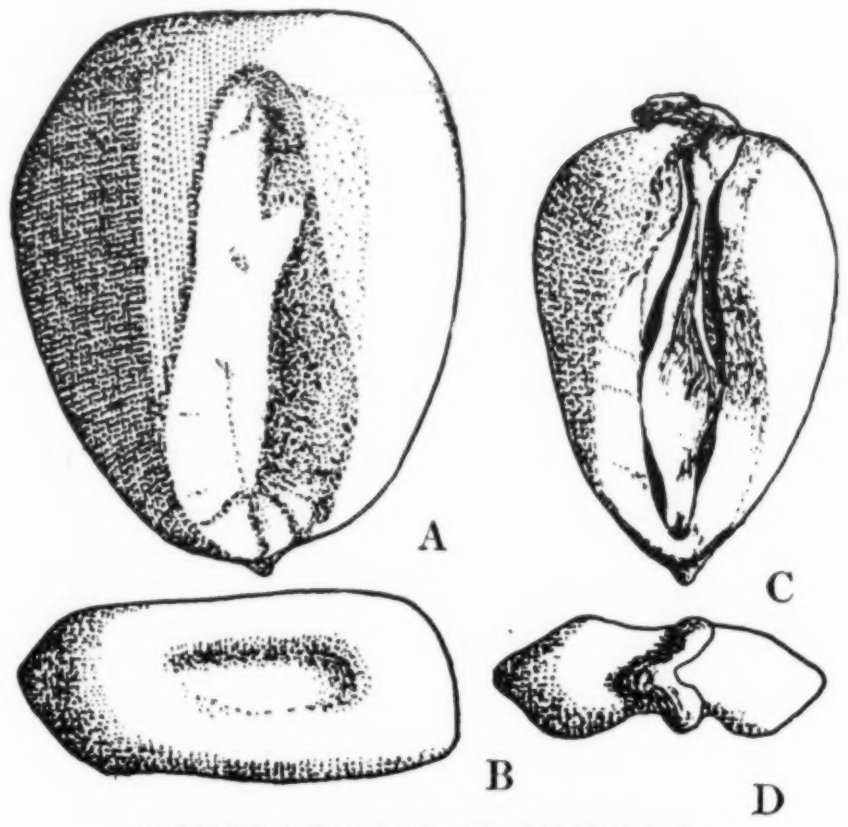
*Contributions from the Botanical Laboratory of Bucknell University. Paper No. 7

This linkage relationship is shown by the summary data in Table II.

The gene Vp_2 has been shown by the writer (Eyster, in press) to be linked with *Pr* with approximately 30 per cent crossing over.

Reduced Endosperm$_2$. Reduced endosperm$_2$ is not very different in its phenotypic expression from that of reduced endosperm$_1$. The general nature of reduced endosperm$_2$ may be seen from the illustration in Figure 9. Kernels showing reduced endosperm$_2$ are, on the average, smaller than reduced endosperm$_1$ and usually less flattened as is shown by the drawing in Figure 11. It would be quite impossible, however, to separate reduced endosperm$_1$ and reduced endosperm$_2$ when produced in the same progeny.

Reduced endosperm$_2$ is inherited as a single Mendelian recessive. An F_2 progeny including a total of 333 kernels consisted of 261 normal and 72 reduced endosperm$_2$ kernels. This is a deviation of 11- from the expected frequencies.



VIVIPAROUS EMBRYOS

Figure 11

A, a kernel with normal endosperm and dormant embryo; *B*, distal end of a kernel with normal endosperm; *C*, a kernel with reduced endosperm$_2$ and viviparous embryo; *D*, distal end of reduced kernel with viviparous embryo. Drawings by Miriam Groner.

The gene for reduced endosperm$_2$, Re_2, is in chromosome VIII very near to that of Vp_2 as may be seen from the comparison in Table III.

TABLE I.—F_2 progenies from the cross $\frac{Re_1}{Re_1} \times \frac{re_1}{re_1}$

	Normal	*Reduced Endosperm*$_1$
Observed Frequencies	2310	810
Expected Frequencies	2340	780
Deviations	−30	+30

TABLE II.—F_2 progenies from the cross $\frac{Re_1\ Vp_2}{Re_1\ Vp_2} \times \frac{re_1\ vp_2}{re_1\ vp_2}$

	Re$_1$ Vp$_2$	Re$_2$ vp$_2$	re$_1$ Vp$_2$	re$_1$ vp$_2$
Observed Frequencies	2058	252	190	620
Expected Frequencies on the basis of linkage with 15.46 per cent crossing over	2117	223	223	557
Deviations	−59	+29	−33	+63

TABLE III.—F_2 progenies from the cross $\frac{Re_2\ Vp_2}{Re_2\ Vp_2} \times \frac{re_2\ vp_2}{re_2\ vp_2}$

	Re$_2$ Vp$_2$	Re$_2$ vp$_2$	re$_2$ Vp$_2$	re$_2$ vp$_2$
Observed Frequencies	257	4	0	72
Expected Frequencies on the basis of linkage with 1.21 per cent crossing over	248	2	2	81
Deviations	+9	+2	−2	−9

RADIATION-INDUCED VARIATION IN COTTON

Somatic Changes Induced in *Gossypium hirsutum* by X-raying Seeds*

W. R. Horlacher and D. T. Killough†

THE success of numerous workers in using short-wave radiations in the production of mutations and chromosome rearrangements in various species points to the universal application of the technique to all living organisms. It is desirable that data be collected as rapidly as possible concerning the possibilities of using this method in the improvement of various plants and animals which are of economic importance.

With this in mind, we have begun a study of the effects of X-rays on cotton, the major farm crop of the southern states. We are at present confining our studies to *Gossypium hirsutum,* American upland cotton.

This paper is a report on the development of the cotton plants grown from X-rayed‡ dry seed.

In accordance with the experience of Goodspeed[1] and of Stadler,[5] we found that the dry cotton seed can withstand very heavy doses of X-rays. A dose of 100 K. V., 5 ma., 17 cm. target distance, for 60 minutes does not lower the germination percentage of good cotton seed appreciably. In one line, Startex 7000, the seeds which we rayed were two years old. These seeds were given the same X-ray treatment as were the seeds of other lines from which we secured normal stands. From the non-rayed seeds of this line of Startex we secured a normal stand, but from 500 rayed seeds we obtained only 24 plants, the germination percentage of this seed having been lowered very markedly. Figure 13 shows the poor stand secured from the X-rayed seed compared with the normal stand secured from the non-rayed seed from this line. We are conducting further tests to determine the relation of the age of the seed to its susceptibility to X-ray treatment.

One of the very quickly noticeable effects of the X-ray treatment is the production of numerous dwarf plants. When the seedlings are a few days old they can be readily divided into three classes with regard to height: normal, intermediate, and dwarf. Figure 12 shows seedlings of these three types. Many of the dwarfs are peculiar in their mode of inflorescence in that each plant has one terminal flower. The normal cotton plant has no terminal flower, but has numerous flowers on the branches.

Branched and Fused Cotyledons

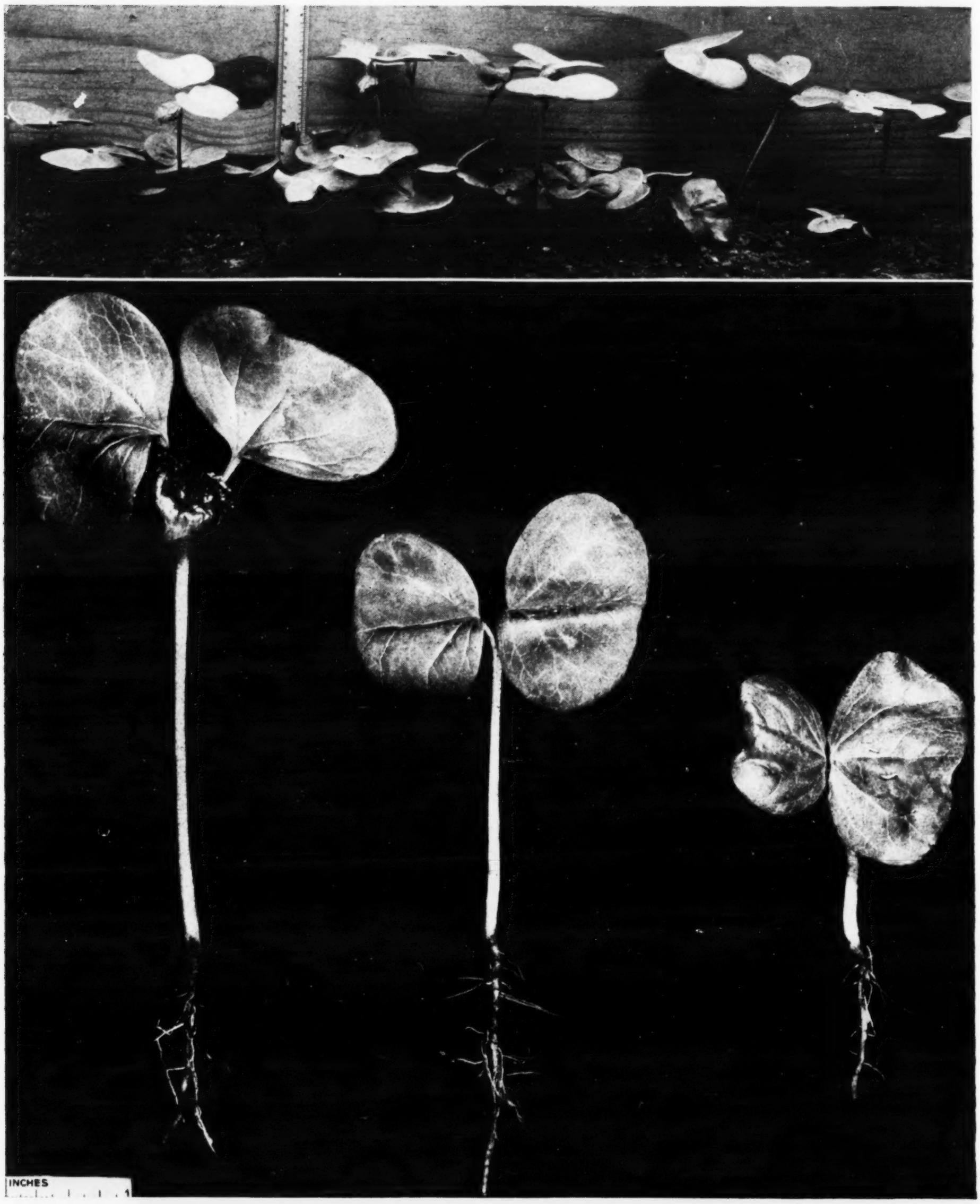
Cotton is a dicotyledonous plant. Among the several hundred seedlings which we grew from X-rayed seeds we observed one seedling which produced three cotyledon leaves, and two seedlings, each of which had only one cotyledon leaf. The seedling which had three cotyledons, Figure 14*D*, had one cotyledon of normal size and development and two which were smaller in size and each of which had fewer

---

*Contribution from the Texas Agricultural Experiment Station, paper No. 142, Technical Series.

†Professor of Genetics, A. and M. College of Texas, and Agronomist in charge of Cotton Breeding, Texas Agricultural Experiment Station, respectively.

‡The authors wish to express their appreciation to Dr. J. E. Marsh, college physician, for his kindness in permitting them to use the X-ray machine belonging to the college hospital, for X-raying the cotton seeds used in this study.



DWARF COTTON PLANTS PRODUCED BY X-RAYING

Figure 12

Cotton seedlings grown in the greenhouse from X-rayed dry seed at a dosage of 100 K. V., 5 ma., 17 cm. target distance for 60 minutes. From 50 seeds treated thus, 36 germinated producing 12 normal seedings (left) and 24 dwarf seedlings of the two types, extra dwarf (right) and intermediate dwarf (center).

EFFECT OF X-RAYS ON TWO-YEAR-OLD COTTON SEED

Figure 13

General view of field, Startex cotton, line 7000, two-year-old seed. Control plants on left showing normal stand. X-rayed plants on right showing very poor stand. X-rays did not have a very marked effect on the germination of fresh seed. Its effect on older seed is being studied further.

than the normal number of veins. Apparently, one cotyledon was split into two parts, while the other developed normally, thus bringing about the production of three cotyledons on this seedling. The cotyledons on the seedlings which developed only one cotyledon each, Figure 14*B* and *C* were large and each had a large number of veins. A line of fusion can be seen near the middle of each of the leaves pictured. The complete fusion of the two petioles on one of these seedlings is shown in Figure 14*A*. This is the same seedling as the one pictured in Figure 14*B*. It is evident from these photographs that the production of only one cotyledon on each of these two seedlings was due to the fusion of the two cotyledons. No seedling with either one or three cotyledons was observed in the controls. The junior author has been making careful observations on cotton seedlings for a number of years and he never had observed previously a cotton seedling that did not have two cotyledons.

Crumpled leaves appeared occasionally on the plants grown from the X-rayed seed. One of these leaves is shown in Figure 17. This leaf was one of the first adult leaves produced on the plant. The shape of this leaf indicates that different parts of it have developed at different rates.

Two Types of Variegation

Another very common effect produced by the X-rays is the production of numerous variegations in the colors of the leaves. The strain in which this was very noticeable is a virescent yellow strain. This leaf color, as has been shown by Killough,[3] is a simple Mendelian recessive to green. The first few adult leaves on the young plants from X-rayed seeds of this strain show variegation in a very large percentage

of the cases. Each plant grown from fifty seeds which were subjected to a dose of 100 K. V., 5 ma. for 60 minutes at a target distance of 17 cm. showed variegation in some of its leaves. Some of the plants grown from seeds subjected to lighter doses also had variegated leaves. Roughly, the amount of variegation in the leaves was proportional to the dosage.

The variegated leaves produced in the virescent yellow strain were of two types, splotched and angular. The splotched type, shown on the left in Figure 15 nearly always has three colors in the leaves. These are green, virescent yellow and white. This condition may be the result of cytoplasmic disturbances or of abnormal chromosome behavior induced by the X-rays. Very probably both factors are operating in these cases.

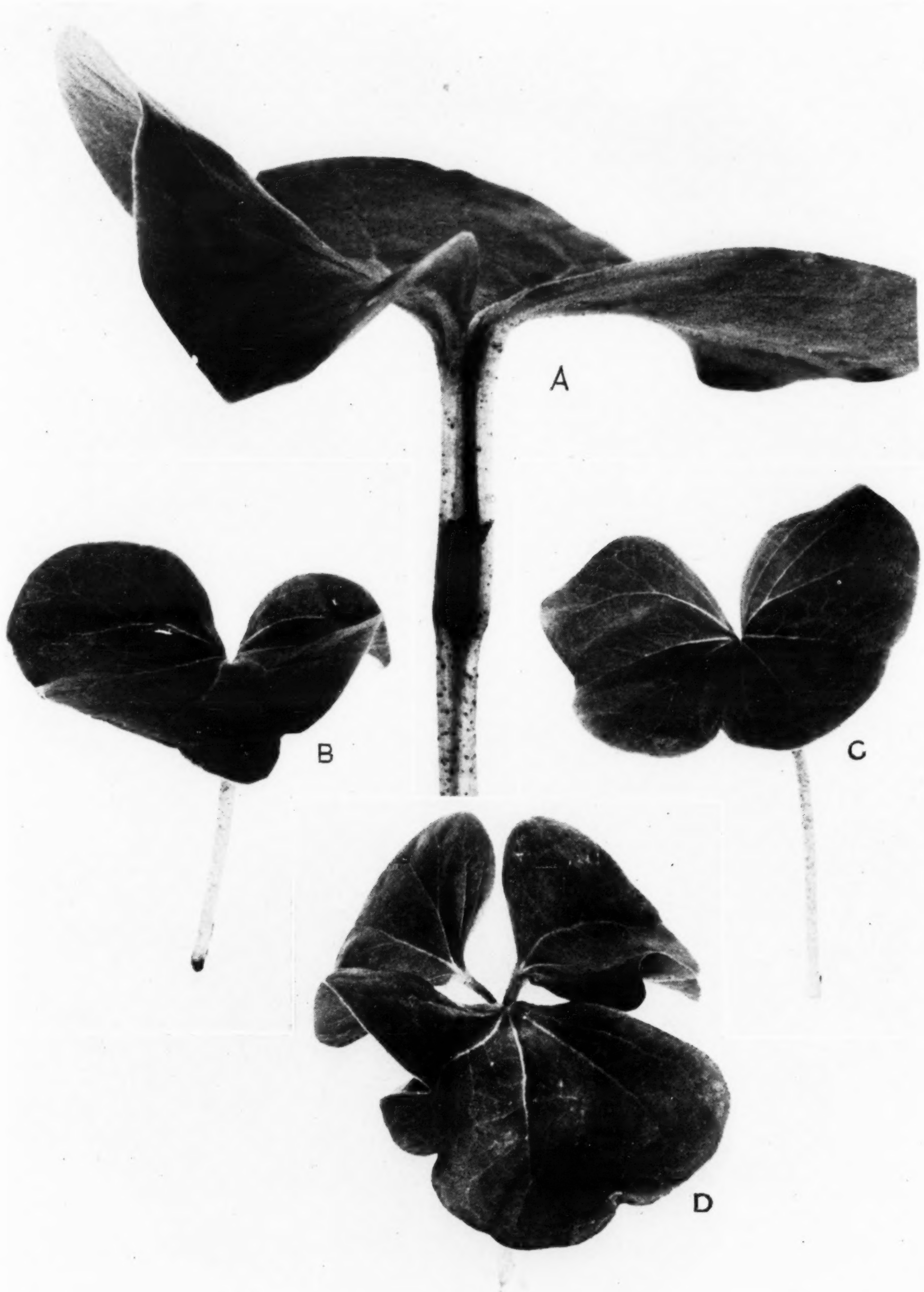
Some examples of the angular variegation, or sectorial chimeras, produced are shown on the right in Figure 15 and in Figure 16. These are of particular interest as being strongly indicative of nuclear changes. An unequal nuclear division early in development will cause different sections of the leaf to develop into different types whenever different genes are disturbed to the two areas. The colorless sections can be accounted for by assuming that the genes for color have become lost from that area. If the radiation should cause a mutation of one gene to albinism and then nondisjunction should occur so that the chromosome bearing the normal allelomorph were lost from the cell, the production of these albino sections of the leaves would be brought about. These albino sections are particularly interesting because albinism has never been reported in cotton.

The green sections of the leaves in the virescent yellow strain are of unusual interest. As stated above, virescent yellow is a simple Mendelian recessive to green. These sections are produced by some disturbance early in the development of the leaf which brings about the development of green color. The logical inference is that there has been a mutation in one member of the allelomorphic pair from virescent yellow to green in the cell which has developed into this section of the leaf. This is a dominant mutation. It has been pointed out elsewhere by Horlacher,[2] that chromosomal rearrangements probably do not bring about the production of dominant areas in recessive tissue. Unfortunately, it is impossible to apply the breeding test to the green areas in these leaf chimeras because thus far no one has succeeded in growing leaf cuttings of cotton.

One plant from X-rayed seed of the virescent yellow line grown to maturity in the field produced only green leaves. This plant was a very poorly developed specimen growing prone on the ground instead of erect as cotton normally grows. Apparently all the growing points were killed by the radiation except one lateral bud which grew into this scraggly plant and in which there was produced a mutation from virescent yellow to green. In other plants from the virescent yellow line some branches have green leaves while others have virescent yellow leaves.

Progressive Changes

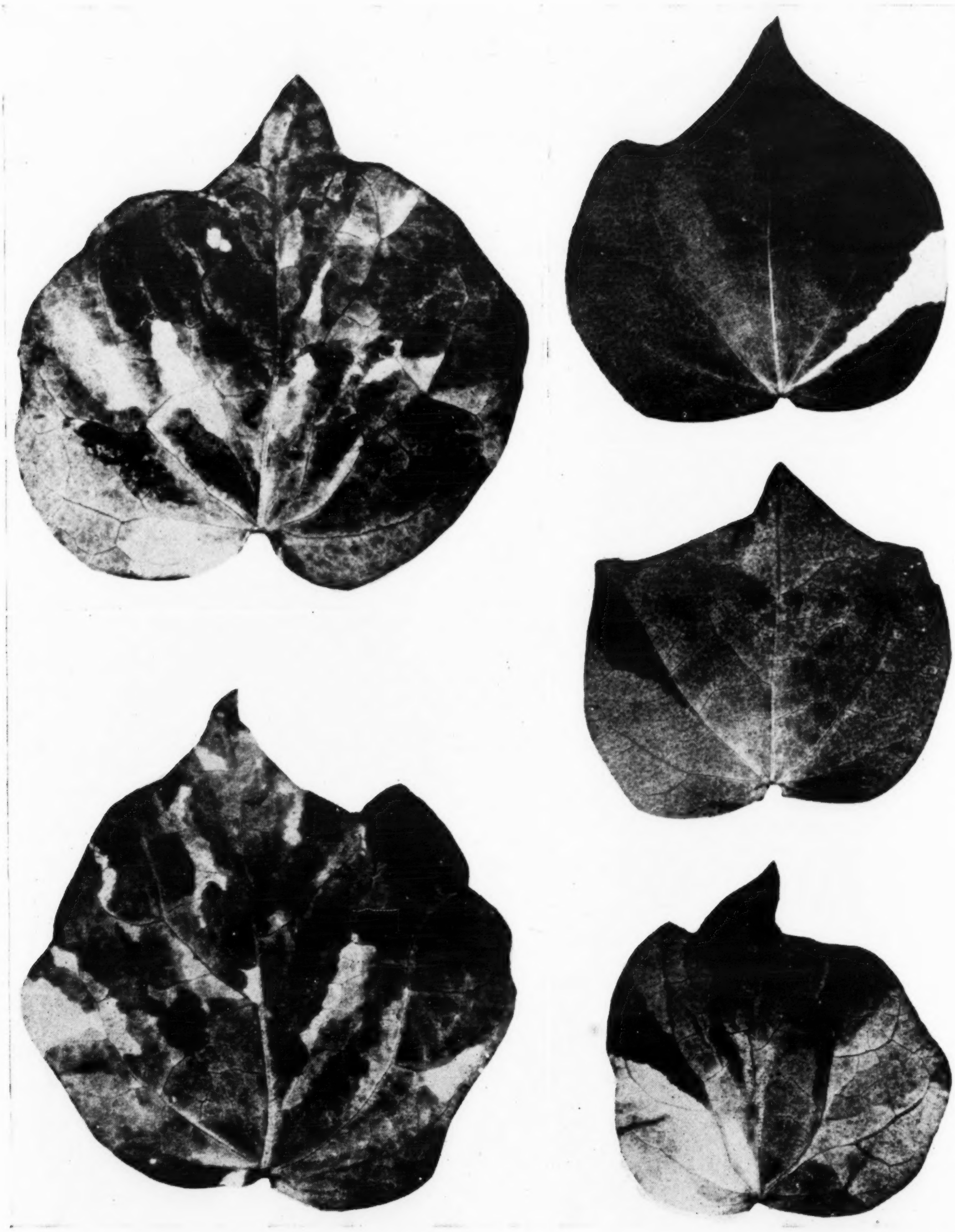
One of the important questions confronting radiation genetics is the question of whether or not radiations produce any changes of a progressive nature. The argument has been advanced that all of the induced changes are destructive, that no variation is produced by radiations that is of any value to the organism or to man. Evidence has been collected by Patterson and Muller[4] and by Timofeeff-Ressovsky[6, 7, 8] that mutations of a progressive nature can be induced in Drosophila. The variation from virescent yellow to green in cotton is a progressive change, the green plant having a greater concentration of chlorophyll than the virescent yellow. The change from forked leaf shape to normal leaf shape reported below might also be considered as a pro-



FUSED AND EXTRA PETIOLES

Figure 14

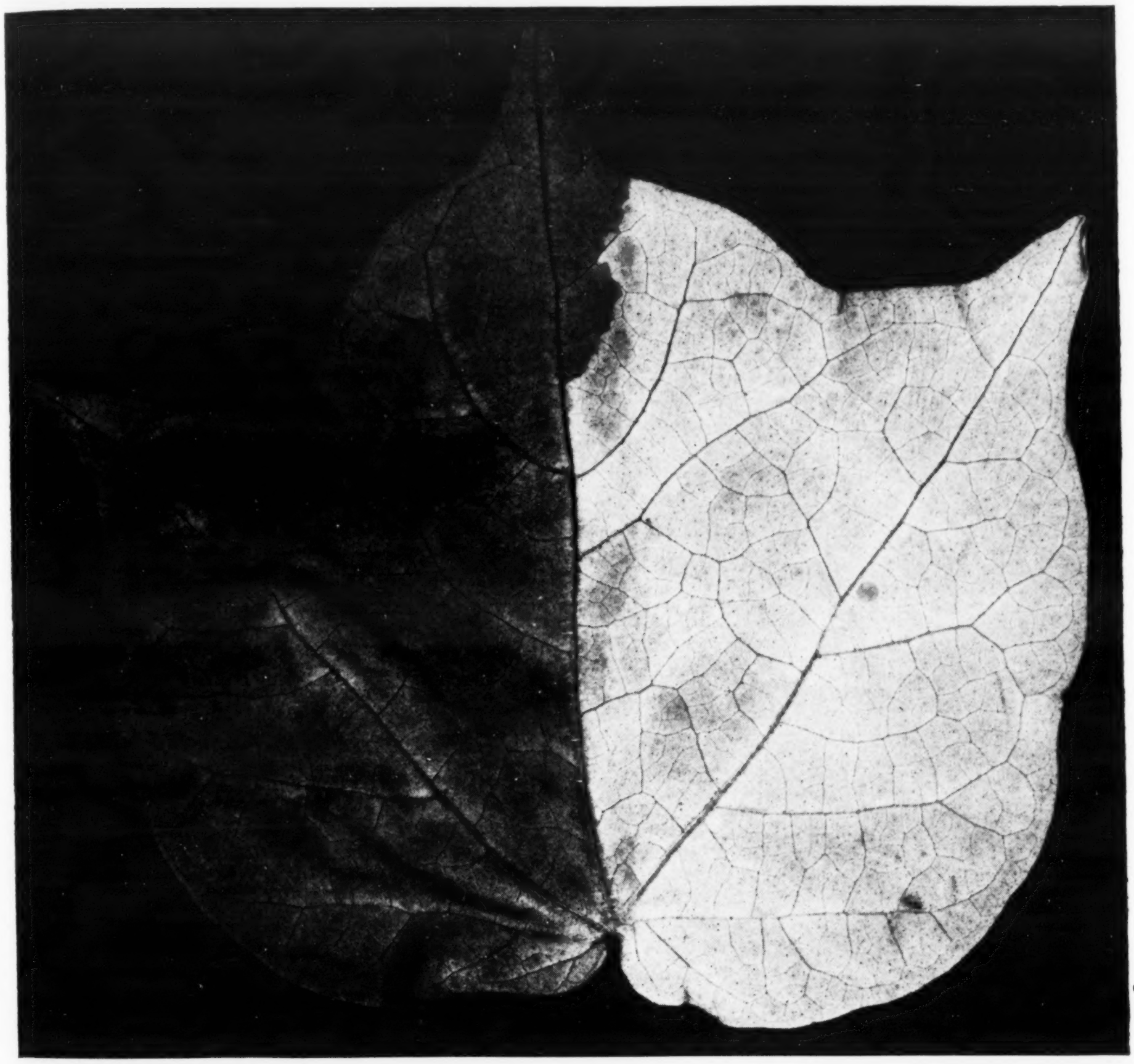
Plants from X-ray treated seed frequently show fusions or splitting of the cotyledons. *A*, a plant in which the cotyledons and their petioles have completely fused. Another view of this plant is shown at *B*, and a view of another plant with fused cotyledons is shown at *C*. Cotton is normally a dicotyledonous plant, but the plant shown at *D*, from X-rayed seed, has three cotyledons instead of two. No seedlings with either one or three cotyledons were observed in the controls, nor in other stands of seedling cotton examined.



SPLOTCHED AND ANGULAR VARIEGATIONS IN ADULT COTTON LEAVES

Figure 15

The first few adult leaves produced by young cotton plants grown from X-rayed seed show variegations in color. Many of them are of the splotched type shown at the left. These leaves are from a strain of virescent yellow cotton. Three color types are shown, the dark areas being green, the lighter areas virescent yellow and the white areas albino. At the right are shown sectorial or angular variegations of cotton leaves produced by X-rays. (See also Figure 16).



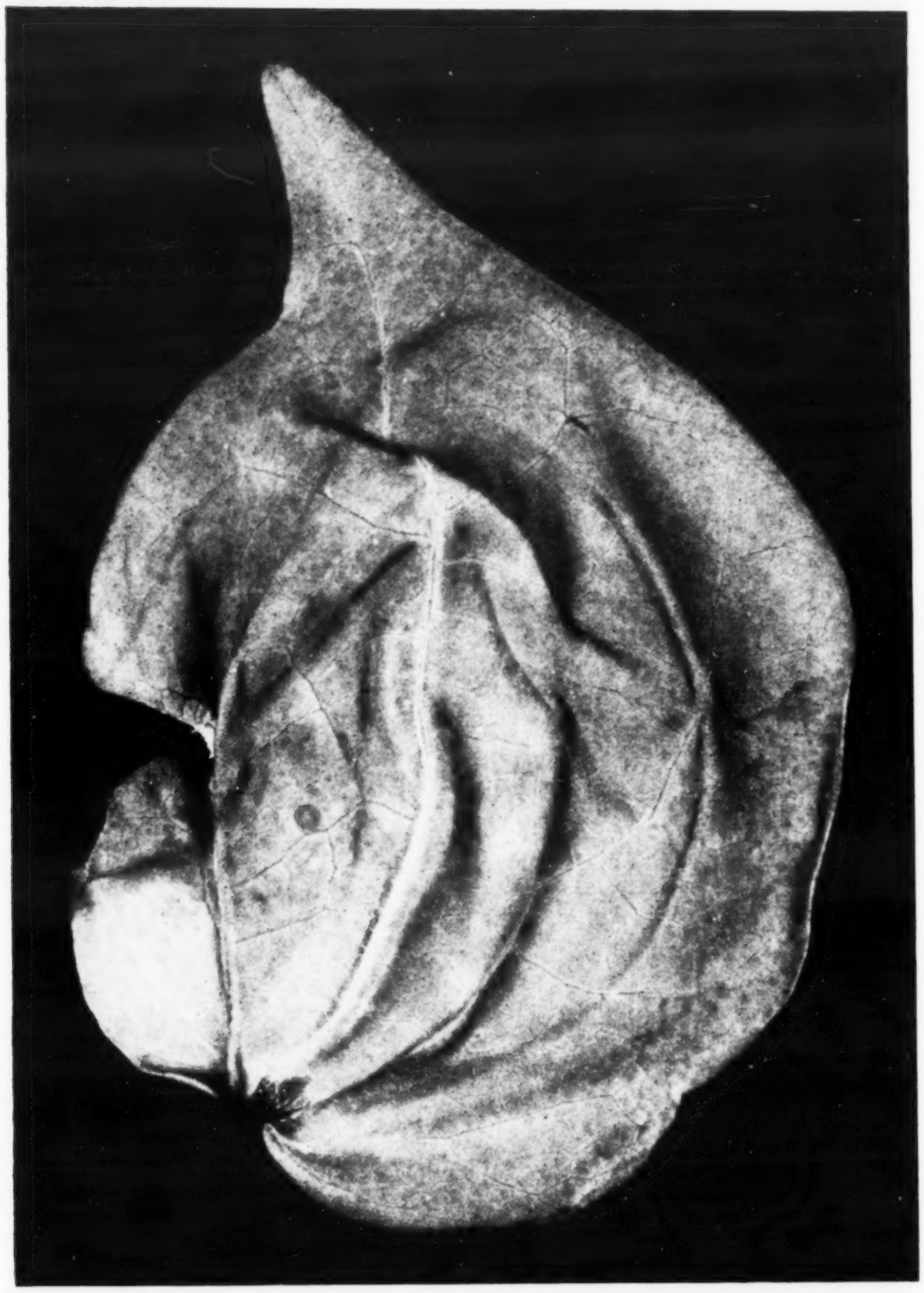
BILATERAL CHIMERA

Figure 16

This is one of the first adult leaves from a cotton plant grown from an X-rayed seed of virescent yellow cotton. The left half of the leaf is green, the right half virescent yellow. The green half of this leaf must be due to a dominant mutation from virescent yellow to green, green being a simple Mendelian dominant to virescent yellow.

gressive change for certain conditions.

Some of the green areas in the variegated leaves of this virescent yellow cotton may be due to chromosomal variations of such a nature that the cells in this area are trisomic or tetrasomic for the chromosome set carrying genes for virescent yellow. The neighboring white or light yellow areas then would be produced by being monosomic for this chromosome set, or, conceivably, the chromosome bearing this gene might be missing entirely from the cells in this area. Should a green area be produced due to this trisomic or tetrasomic condition, it would be accompanied by a neighboring area of light yellow or white which is monosomic, or which has no chromosome of this set. Likewise, a green area due to the condition outlined above in which a mutation from color to albinism accompanied by non-disjunction was assumed, would be accompanied by



CRUMPLED LEAF RESULTING FROM X-RAY TREATMENT

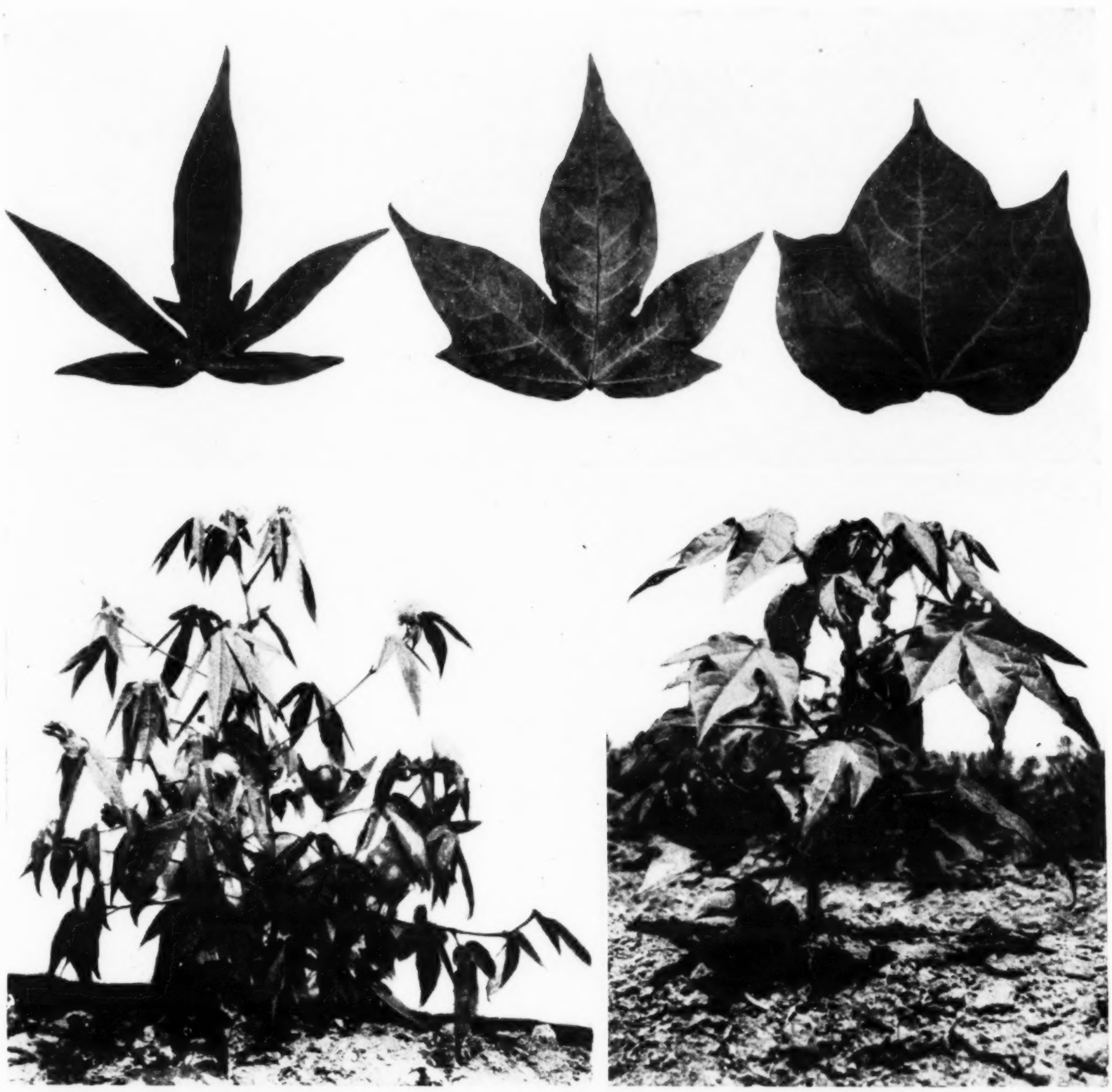
Figure 17

The crumpled condition is an abnormality which is characteristic of some leaves produced on cotton plants grown from X-rayed seed. Irregularity in growth is one of the common effects produced in cotton by radiations.

a neighboring area of white. The green areas in the leaves with variegation of the splotched type and in some of those with angular variegation are accompanied by such light colored areas. But some of the leaves with angular variegation, such as the leaf at the right center in Figure 15 and the leaf in Figure 16, have green sections on leaves which are all virescent yellow outside of these sections. In these cases the green area must be due to a gene mutation from virescent yellow to green. The green plant produced from the virescent yellow strain by radiation illustrates the same change affecting the entire plant.

While the evidence presented here for "progressive" mutations is based entirely on changes in the somatic tissue, when it is supported by such evidence as that obtained by Patterson and Muller and by Timofeeff-Ressovsky, it can leave little doubt but that favorable mutations can be induced in cotton. Thus there is evidence that radiations can cause "progressvie" mutations in plants as well as in animals. The fact that this type of mutations can be induced offers the possibility of a much deeper insight into the mechanism of organic evolution. It also offers to the breeder a technique for producing variations of a desirable nature which he may incorporate into the strains he is seeking to improve.

The normal cotton plant has a central stem and numerous branches. Several of the plants from X-rayed seed had no central stem the plant developing from one or more of the branches. Evidently in these plants the terminal buds were killed by the



CHANGE IN LEAF SHAPE INDUCED BY X-RAYS

Figure 18

Above, homozygous forked leaf on left. Intermediate leaf shape produced on a plant grown from an X-rayed seed of homozygous forked leaf strain in the center. Homozygous normal leaf shown on right for comparison. The intermediate leaf shape is typical of the F_1 generation from a cross of homozygous forked leaf and homozygous normal leaf cotton.

Below, a homozygous forked leaf plant from the control is shown on the left. The plant on the right which has leaves intermediate in shape was grown from an X-rayed seed of this same homozygous forked leaf line.

radiations. One or more lateral buds then developed into the principal portion of the plant.

Leaf-Shape Mutations

A character in cotton of which the inheritance is well known and which is very easily recognized is leaf shape. The two general types are normal leaf shape and forked leaf shape (often called okra leaf). In the normal leaf the lobes are broad and the indentations between the lobes are not very deep. The lobes of the forked leaf are very narrow, almost pencil-like, and the indentations are

very deep. Genetic studies made by several different workers have shown that a single pair of genes accounts for this difference in leaf shape. The leaf of the heterozygous plant is intermediate in shape between the shapes of the two homozygous types.

We X-rayed five hundred seeds of a line of forked leaf cotton to determine whether or not this gene can be changed. Six plants grown from these seeds produced leaves which are intermediate in shape, the leaf shape of the heterozygous plant. Figure 18 shows three cotton leaves, the leaf on the left being from a true breeding forked leaf line, the leaf on the right from a true breeding normal leaf line, and the leaf in the middle, which is intermediate in shape, was taken from one of the six plants mentioned above. Figure 18 shows also two cotton plants, the one on the left having forked leaves and the one on the right having leaves which are intermediate in shape. This plant was grown from an X-rayed seed of the forked leaf line. Several other plants from this rayed forked leaf line have forked leaves on some branches and leaves of intermediate shape on others.

These changes from forked leaf to intermediate leaf shape furnish good evidence that gene mutations have been produced in the somatic tissues of the plants in which the changes occurred. As soon as it is possible to grow another generation, we will grow the seeds from these plants. We will then be able to determine definitely whether or not gene mutations have been produced. If they have, the progeny from self fertilizing these plants will segregate into a ratio of 1 normal leaf: 2 intermediate leaf: 1 forked leaf, just as would the progeny resulting from the self fertilization of an F_1 plant which was produced by crossing a normal leaf plant with a forked leaf plant.

Five hundred seeds of red leaf cotton were X-rayed, also. No somatic changes were observed in the plants grown from the X-rayed seeds.

In connection with this work we have X-rayed cotton pollen and used this in pollination. This work has just been initiated, no plants having as yet been grown from the resulting seeds.

Literature Cited

1. Goodspeed, T. H. The effects of X-rays and radium on species of the genus Nicotiana. *Jour. Hered.* 20: 243-260. 1929.

2. Horlacher, W. R. Studies on inheritance in pigeons, VII. Inheritance of red and black color patterns in pigeons. *Genetics* 15: 312-346. 1930.

3. Killough, D. T. Texas Agricultural Experiment Station, 42nd Annual Report: 51-52. 1929.

4. Patterson, J. T., and Muller, H. J. Are "progressive" mutations produced by X-rays? *Genetics* 15: 495-577. 1930.

5. Stadler, L. J. Some genetic effects of X-rays in plants. *Jour. Hered.* 21: 3-19. 1930.

6. Timofeeff-Ressovsky, N. W. The effect of X-rays in producing somatic genovariations of a definite locus in different directions. *Amer. Nat.* 63: 118-124. 1929.

7. ————. Rückgenovariation und die Genovariabilitat in Verschiedenen Richtungen. I. Somatische Genovariationen der Gene W, w^e und w bei Drosophila melanogaster unter dem Einfluss der Roentgenbestrahlung. *Roux' Arch. f. Entw Mech.* 115: 620-635. 1929.

8. ————. Reverse genovariations and gene mutations in different directions. II. The production of reverse genovariations in *Drosophila melanogaster* by X-ray treatment. *J. Hered.* 22:67-70. 1931.

First Plant Patent Issued

THE first patent to be granted to the inventor of a new variety of plant, under the revised patent law, was issued on August 18 to Henry Bosenberg for an everblooming variation of the Van Fleet climbing rose. Some interesting questions are raised by this first patent which will be discussed in an early number of the Journal.